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**Chronology of Cosmonaut Flight on 'Mir'
Complex (21 Dec 87 - 4 Jan 88)**

Launch of 'Soyuz TM-4' Spacecraft
18660072 Moscow PRAVDA in Russian 22 Dec 87 p 1

[TASS Report]

[Text] In line with the program of research on outer space, the spaceship "Soyuz TM-4" was launched from the Soviet Union on 21 December 1987, at 1415 hours Moscow time. The spaceship is manned by a crew consisting of Colonel Vladimir Georgiyevich Titov, pilot-cosmonaut of the USSR and the ship's commander; Musa Khiramanovich Manarov, the flight engineer; and Anatoliy Semenovich Levchenko, cosmonaut-researcher.

The mission program calls for the "Soyuz TM-4" ship to dock with the scientific research complex "Mir."

The crew of the orbiting complex "Mir," cosmonauts Yuriy Romanenko and Aleksandr Aleksandrov, who have been working in near-Earth orbit for a prolonged period of time, will be replaced in the course of the joint mission.

The onboard systems of the "Soyuz TM-4" ship are functioning normally. Comrades Titov, Manarov and Levchenko are feeling well.

(A photograph is given showing a launch rocket on a carrier.)

FTD/SNAP /08309

**Biosketches of Cosmonauts Titov, Manarov, and
Levchenko**

18660073 Moscow PRAVDA in Russian 22 Dec 87 p 1

[Text] Pilot-cosmonaut of the USSR Vladimir Georgiyevich Titov was born on 1 January 1947, in the city of Sretensk, Chita Oblast.

After graduating in 1970 from the Chernigov Higher Military Aviation School for Pilots, he served as a pilot-instructor in the Air Force, and subsequently as a flight commander of an aviation regiment. He has mastered several types of airplanes. He has the qualifications "Military Pilot 1st Class" and "Test-Pilot 3rd Class."

V.G. Titov has been a member of the Communist Party of the Soviet Union since 1971.

Vladimir Georgiyevich was enrolled in the cosmonaut contingent in 1976. He made his first space flight in April of 1983, as the commander of the spaceship "Soyuz T-8."

In 1987, without leaving his regular job, V.B. Titov graduated from the Air Force Academy imeni Gagarin.

Musa Khiramanovich Manarov was born in Baku on 22 March 1951.

After graduating in 1974 from the Moscow Aviation Institute imeni Ordzhonikidze, he was employed in a design bureau. He worked on preparing and conducting tests of space technology and on analyzing experiments that were conducted. He proved himself to be an erudite specialist with much initiative. As the flight director of an operating shift, he has taken part in controlling the flight of the orbiting station "Mir."

M.Kh. Manarov has been a member of the Communist Party of the Soviet Union since 1980.

He was enrolled in the cosmonaut contingent in 1978. He has passed the complete course of training for flights on the "Soyuz TM" spaceship and the orbiting complex "Mir."

Anatoliy Semenovich Levchenko, a meritorious test-pilot of the USSR, was born on 21 May 1941, in the city of Krasnokutsk, Kharkov Oblast.

After graduating in 1964 from the Chernigov Higher Military Aviation School for Pilots, he served in the Air Force.

A.S. Levchenko has been a member of the Communist Party of the Soviet Union since 1965.

After graduating from a school for test-pilots, Anatoliy Semenovich was engaged in testing work from 1971. He has the qualification "Test-Pilot 1st Class."

A.S. Levchenko began to train for space flights in 1978. He has passed the complete course of training for flight on the "Soyuz TM" spaceship and the orbiting complex "Mir."

(A photograph of the three "Soyuz TM-4" cosmonauts in their spacesuits is given. A large structure bearing the letters "SSSR—SOYUZ—TM" appears in the background.)

FTD/SNAP /08309

**Comments on Quality of Equipment on 'Mir'
Station**

*18660074 Moscow IZVESTIYA in Russian
22 Dec 87 p 1*

[Article by A. Ivakhnov, correspondent]

[Excerpt] USSR pilot-cosmonaut Vladimir Titov, commander of the crew [of "Soyuz TM-4"], needs no introduction; details of his biography were related in the spring of 1983, when the spaceship "Soyuz T-8" lifted off to meet the orbiting station "Salyut-7."

I met V. Titov again early in 1987, when crews were being introduced to journalists at the Cosmonaut Training Center imeni Gagarin. One of these crews was to be sent on a prolonged mission on board the "Mir" station.

Vladimir very much wanted his crew to be named the primary one. The condition of the flight engineer's health aroused doubts among medical personnel, however. At a meeting of the state commission which was held at the cosmodrome, it was decided that others—Yuriy Romanenko and Aleksandr Laveykin—would occupy the spaceship. The next stage of training exercises began for Vladimir.

The whole crew [of "Soyuz TM-4"] was asked: "Are you satisfied with the equipment with which you will have to work on board 'Mir'?"

"It cannot be said that the workmanship of all of the instruments and equipment that are sent into orbit is on the highest world level. It is no secret that 'Kiev' cameras often jam in space, for example, and that in zero gravity, crystals pop out of watches made by Moscow Watch Plant No 1, although the enterprises guarantee us high quality of these products.

Malfunctions occur also in equipment intended for research and experiments. There are masters of the highest class among the people who make this equipment, and there are also those who take a less responsible attitude toward their work. Cosmonauts report their comments and make suggestions after each mission."

FTD/SNAP 08309

Emergency Rescue During Earlier Launch With Cosmonaut Titov Recalled

18660075 Moscow TRUD in Russian 22 Dec 87 p 4

[Article by V. Golovachev, special correspondent at the Flight Control Center]

[Excerpt] Vladimir Titov first took off into space with G. Strekalov and A. Serebrov in "Soyuz T-8," on 20 April 1983. But they never succeeded in docking with the station "Salyut-7" that time, because of an equipment failure.

Some time afterward, Titov and Strekalov were again to be sent into orbit.

Malfunctions occurred in a system of the launch rocket, and it began to burn. When this information was received at the control bunker, only instants remained for making a decision.

It is appropriate to recall that there is a special emergency rescue system on Soviet spaceships of the "Soyuz" type. In the event of danger, solid-propellant engines drive the ship sharply upward and sideways, away from the rocket; the cosmonauts then return to Earth in the

reentry vehicle on a parachute. This system can be activated by the cosmonauts themselves or by automation equipment. During a launch, the signal that activates the system can be transmitted also from the control bunker, but only on the condition that this command is given simultaneously by the two specialists who are responsible for the rocket and the spaceship.

The rescue system had been tested many times before being installed in the rocket, of course. Flights were made by dummies and animals, but no tests with human being were conducted. I do not know why they were not — because of reluctance to subject people to excessive risk or because of confidence in the new system, perhaps, or it may have been thought that the likelihood of having to use the system in practice, during a launch, was insignificantly small, taking into account the high reliability of our rockets. It is hard to say. In any case, Titov and Strekalov became the first to test the system during an actual launch.

FTD/SNAP /08309

Specialists Comment on 'Mir' Crew's Materials Research, State of Health

18660076 Moscow SOVetskaya Rossiya in Russian 22 Dec 87 p 4

[Article by Aleksandr Nemov]

[Abstract] The article records comments on three specialists regarding work which cosmonauts Yuriy Romanenko and Aleksandr Aleksandrov were doing during the last weeks of their mission on board the orbiting complex "Mir." Valeriy Fedorovich Domashev, head of a Flight Control Center group for analysis of scientific experiments, and Rashid Aliyevich Syunyayev, corresponding member of the USSR Academy of Sciences and scientific director of the experiment complex "Rentgen," are quoted in regard to Earth-resources, materials-science and supernova studies which the crew of "Mir" was conducting. Candidate of Medical Sciences Oleg Dmitriyevich Anashkin, a representative of the medical support service for the mission, mentioned results of medical monitoring of the cosmonauts.

The onboard control computer of the "Mir" complex has more efficiency as compared with earlier space stations, Domashev related. Whereas approximately 4,000 experiments were performed during earlier missions on board orbiting stations, about 1,000 had been performed during Romanenko's and Aleksandrov's mission alone. Domashev mentioned in particular that the cosmonauts had obtained lead-tin-tellurium semiconductor crystals of extremely high quality in the onboard unit "Korund," using special temperature routines.

Anashkin related that the cosmonauts' state of health had remained within permissible limits during the final phase of their mission. Romanenko's weight had dropped by 1.6 kilograms, while Aleksandrov had gained

2.3 kilograms. Conscientious adherence to a set of preventive measures had enabled the crew to combat effects of weightlessness successfully over the course of the mission, Anashkin explained. Romanenko had 'logged' about 1,000 kilometers on the running track and stationary bicycle, for example. A total of 170 medical examinations of 34 different types had been performed on the crew. Anashkin mentioned that a whole set of special measures had been prescribed for the purpose of preparing the cosmonauts for their return to Earth. In particular, the duration of their physical conditioning exercises was increased to 2.5 hours a day beginning 21 October, exercises with the pneumatic vacuum suit "Chibis" had been included in the conditioning program, and multivitamin preparations were included in the crew's diet beginning 12 December. Romanenko's mission has demonstrated conclusively that it is safe for a human being to remain in orbit for periods of seven to eight months, according to Anashkin.

FTD/SNAP 08309

'Soyuz TM-4' Docks With 'Mir' Complex

18660077 Moscow IZVESTIYA in Russian
25 Dec 87 p 1

[TASS Report]

[Text] On 23 December at 1551 hours Moscow time, the manned spaceship "Soyuz TM-4" docked with the scientific research complex "Mir," on board which cosmonauts Yuriy Romanenko and Aleksandr Aleksandrov are working.

After checking the seal of the docking mechanism, Vladimir Titov, Musa Manarov and Anatoliy Levchenko went inside the station at 1720 hours.

The five Soviet cosmonauts' mission on board the "Mir" complex is scheduled for seven days. The cosmonauts are to perform a series of scientific-technical and medical-biological experiments in the course of joint work. Experience with operation of equipment and apparatus of the permanent manned complex will be passed on to the new crew by Yuriy Romanenko and Aleksandr Aleksandrov.

After planned work is completed, cosmonauts Yuriy Romanenko, Aleksandr Aleksandrov and Anatoliy Levchenko will return to Earth in the spaceship "Soyuz TM-3," and Vladimir Titov and Musa Manarov will continue work in near-Earth orbit.

The onboard systems of the "Mir" complex are functioning normally. The cosmonauts are continuing to carry out the mission program.

FTD/SNAP 08309

Work Program of 5-Man Crew Aboard 'Mir'

18660078 Moscow PRAVDA in Russian 25 Dec 87 p 1

[TASS Report]

[Text] Flight Control Center, 24 December. Yuriy Romanenko, Aleksandr Aleksandrov, Vladimir Titov, Musa Manarov and Anatoliy Levchenko are working jointly for the second day on board the orbiting complex "Mir."

The research program of the mission includes biotechnology, technical and biological experiments today. As usual, the cosmonauts are performing a large volume of medical research during the first days of their stay on board the complex, for the purpose of further studying processes of the human organism's adaptation to weightlessness.

Experiments in line with the program of biotechnology research have begun in units called "Aynur" and "Ruchey." The first of these is intended for growing crystals of a vegetable protein; electrophoretic separation and purification of various biologically active substances are done in the second unit.

As has been reported, Yuriy Romanenko, Aleksandr Aleksandrov and Anatoliy Levchenko will return to Earth in the spaceship "Soyuz TM-3." For this purpose, the cosmonauts are to dismantle the individual base of Levchenko's chair on the "Soyuz TM-4" ship and install it in the reentry vehicle of "Soyuz TM-3" in the course of the day.

According to telemetry data and reports from orbit, the flight of the scientific research complex "Mir" is proceeding normally.

The five Soviet cosmonauts are feeling well, and their morale is good.

FTD/SNAP 08309

Cosmonaut Levchenko To Pilot Aircraft Immediately After Deorbit

18660079 Moscow PRAVDA in Russian 25 Dec 87 p 6

[Article by A. Pokrovskiy, special correspondent at the Flight Control Center]

[Excerpt] The first member of [the crew of "Soyuz TM-4"] to be debriefed will be Anatoliy Levchenko. This experienced pilot will return to Earth with Yuriy Romanenko and Aleksandr Aleksandrov. Strange as it sounds, this landing will mark not the end but the beginning of a mission for him. The problem is that space technology and aeronautical engineering are both advancing. This means that operators capable of functioning in conditions of both zero gravity and gravitation will be needed for controlling new craft which will appear. Igor Volk became the first such operator, and Anatoliy Levchenko

will now become one. After his spacecraft has landed, physicians plan to test features of his reactions while controlling an airplane immediately following his stay in zero gravity. These tests will be conducted while he is seated at the steering wheel of the aircraft.

"The third congress of the Association of Participants of Space Flights took place quite recently in Mexico," related A. Leonov, deputy head of the Cosmonaut Training Center. "Cosmonauts from different countries discussed a number of programs at this congress. Topics of discussion included possibilities for a joint flight of a space shuttle and the 'Mir' station, development of a common system for rescue operations in space (an androgynous docking mechanism which was developed for the joint flight of 'Soyuz' and 'Apollo' has been put aside for some reason or other), creation of a lunar base, and a mission to Mars. How to realize all of these things is the main question, of course. Prolonged missions such as those which Romanenko and Aleksandrov are completing and Titov and Manarov have begun are important also in connection with preparations for such projects, as is the experiment which Levchenko is to carry out. International cooperation which would utilize space-mission experience amassed primarily in the USSR and the USA is still necessary in such complex programs."

FTD/SNAP 08309

New 'Mir' Crew Continue Adaptation to Weightlessness

18660080 Moscow PRAVDA in Russian 26 Dec 87 p 1

[TASS Report]

[Text] Flight Control Center, 25 December. Yuriy Romanenko, Aleksandr Aleksandrov, Vladimir Titov, Musa Manarov and Anatoliy Levchenko are working together for the third day on board the orbiting complex "Mir."

Medical-biological and biotechnology experiments and visual observations of the Earth's surface are on the program today.

The newly arrived crew is performing one more series of medical studies for the purpose of evaluating the condition of the human organism during the stage of adaptation to weightlessness and determining the effectiveness of preventive agents employed during this period.

Experiments aimed at perfecting a basic process for obtaining highly pure biologically-active substances in conditions of extremely small gravitation are continuing. An antiviral preparation is being purified in the electrophoretic unit "Ruchey" today.

In line with the plan for passing on experience amassed during prolonged work in orbit, Yuriy Romanenko and Aleksandr Aleksandrov are familiarizing Vladimir Titov

and Musa Manarov with features of the operation of individual onboard systems and equipment of the scientific research complex "Mir."

The flight is proceeding normally.

The cosmonauts are feeling well.

FTD/SNAP 08309

Biotechnology Equipment, Experiments on 'Mir' Complex

18660081 Moscow PRAVDA in Russian 27 Dec 87 p 1

[Article by A. Tarasov, special correspondent at the Flight Control Center]

[Text]At present, the greater part of the time of the joint mission of Yuriy Romanenko, Aleksandr Aleksandrov and the crew of "Soyuz TM-4" is given over to the task of handing over and accepting the "Mir" complex.

One wall of the "Kvant" module might well be called the biotechnology section. A whole set of equipment is there. It now includes three units: the "Svetlana," which arrived with the module itself; a unit called "Ruchey," which was delivered by the Soviet-Syrian crew; and one called "Aynur," which the "Soyuz TM-4" crew brought.

When Aleksandrov and Musa Manarov begin to perform magic with biotechnology ampoules and receptacles, two organizers of these experiments hurry to communications stations. They are Candidate of Medical Sciences Andrey Lepskiy, a USSR State Prize laureate, and Oleg Mitichkin, associates of the Main Administration for Development and Use of Space Technology for the Economy and Scientific Research. They began with the very first unit, "Tavriya," which was tested during the mission of L. Popov, A. Serebrov and S. Savitskaya. What is new on board now?

The "Aynur" turns out to be not an electrophoretic unit but a biological crystallizer. It should be mentioned that this instrument was given its beautiful woman's name by its builders and designers of the Azerbaydzhan Academy of Sciences. The longest of the current experiments, "Aynur" will be continuously in progress for five days. Protein crystals have been maturing all this time in four trays in the unit. This rare product is a most essential one for science; its crystalline structure will help specialists make X-ray analyses of the protein and trace combinations of its atoms and molecules with the aid of data processed by computers.

Scientists of the USSR Academy of Sciences' Institute of Bioorganic Chemistry imeni Shemyakin, which is headed by academician Yu. Ovchinnikov, supplied a preparation for crystallization in zero gravity, and they are providing scientific guidance for this experiment.

A portion of interferon obtained by genetic engineering was prepared at the same institute, in its experimental production facility. This preparation is undergoing final high purification in the "Ruchey" unit. Not liters or kilograms of it; a few milliliters of the preparation are enough for many therapeutic doses.

Final improvements were made in the "Ruchey" following mission tests in line with the Soviet-Syrian program, and the unit has been reactivated with excellent results.

FTD/SNAP 08309

Briefing of Replacement Crew, Experiments Continue on 'Mir'

18660082 Moscow IZVESTIYA in Russian
27 Dec 87 p 1

[TASS Report]

[Text] Flight Control Center, 26 December. The transfer of duty is continuing on board the orbiting scientific research complex "Mir."

Work experience with tending scientific apparatus of the astrophysical module "Kvant" and performing operations connected with egresses into open space is being shared with the new crew today by the space complex's long-term occupants, Yuriy Romanenko and Aleksandr Aleksandrov.

In line with the program of biotechnology experiments, electrophoretic purification of interferon obtained by genetic engineering is in progress in the "Ruchey" unit.

Aquarium fish, tissue cultures of vegetable and animal origin, and decorative plants were delivered to the complex in the spaceship "Soyuz TM-4" for the purpose of further studying effects of spaceflight factors on various biological specimens.

The day's agenda calls also for technical experiments, motion-picture photography of joint activities, and a television report.

Results of radio conversations and medical monitoring data indicate that the process of adaptation to weightlessness by Vladimir Titov, Musa Manarov and Anatoliy Levchenko is proceeding normally. All five cosmonauts are feeling well.

FTD/SNAP 08309

Astronomy, Biotechnology Studies Aboard 'Mir'

18660083 Moscow IZVESTIYA in Russian
28 Dec 87 p 2

[TASS Report]

[Text] Flight Control Center, 27 December. The latest working day on board the scientific research complex "Mir" began at 0800 hours and will last until 2300 hours Moscow time.

Today the program of work includes astrophysical and biological research, geophysical and biotechnology experiments, and monitoring checks of onboard systems of the transport spaceships.

Several more series of experiments are planned within the framework of the "Rentgen" international program of extra-atmospheric astronomy research."

Biotechnology experiments that are being conducted for the purpose of obtaining crystals of a vegetable protein in zero gravity are continuing in the unit "Aynur."

Conditioning exercises employing the pneumatic vacuum suit "Chibis" will be conducted in accordance with the schedule of preparations for Yuriy Romanenko's and Aleksandr Aleksandrov's return to Earth.

The newly arrived crew—cosmonauts Vladimir Titov, Musa Manarov and Anatoliy Levchenko—are continuing to familiarize themselves with features of the operation of scientific equipment on board the station.

According to reports from orbit and telemetry data, the flight of the orbiting complex is proceeding in line with the designated program.

FTD/SNAP 08309

Cosmonauts Prepare to Return to Earth in 'Soyuz TM-3'

18660084 Moscow PRAVDA in Russian 29 Dec 87 p 1

[TASS Report]

[Text] Flight Control Center, 28 December. The program of joint work of the five Soviet cosmonauts on board the manned complex "Mir" is nearing completion. Yuriy Romanenko, Aleksandr Aleksandrov and Anatoliy Levchenko will return to Earth on 29 December and Vladimir Titov and Musa Manarov will continue their mission in orbit.

Final space-medicine and biological studies are being conducted today, and an experiment for growing crystals of a vegetable protein in the "Aynur" unit is being completed.

Preparations have begun for the descent of the spaceship "Soyuz TM-3" from orbit. The cosmonauts are moving documents, exposed motion-picture and photographic film, recording tapes and biological specimens in containers into the spaceship's reentry vehicle, and used equipment is being moved into its living compartment. Materials from research carried out during the prolonged mission and research which the two crews performed in the process of turning over the complex to a new shift of cosmonauts will be delivered to Earth.

According to telemetry data and reports of the cosmonauts, the work in orbit is proceeding in line with the designated program.

FTD/SNAP 08309

**Cosmonauts Romanenko, Aleksandrov, Laveykin
Return to Earth 29 December**

18660085 Moscow *SOVETSKAYA ROSSIYA* in
Russian 30 Dec 87 p 1

[Excerpt] Cosmonauts Yuriy Romanenko, Aleksandr Aleksandrov and Anatoliy Levchenko returned to Earth on 29 December 1987, at 1216 hours Moscow time, after successfully completing a program of scientific-technical research and experiments on board the manned complex "Mir."

The reentry vehicle of the spaceship "Soyuz TM-3" made a landing 80 kilometers from the city of Arkalyk. The cosmonauts were feeling well after the landing. Vladimir Titov and Musa Manarov are continuing work in orbit.

A manned mission lasting 326 days was carried out by cosmonaut Yu.V. Romanenko, for the first time in history. Complete replacement of the crew of the scientific research complex "Mir" was accomplished while the complex was functioning continuously.

X-radiation of a supernova in the Large Magellanic Cloud was recorded for the first time in the world by telescopes of the "Kvant" module. More than 500 periods of research of various astrophysical objects were conducted in all. With the aid of the ultraviolet telescope "Glazar," 270 photographs of sections of the starry sky were obtained.

A set of preventive measures enabled the crew's commander to accomplish his mission of record duration.

Soviet cosmonautics is ending the year of the 70th anniversary of the October Revolution with outstanding successes. Effective operation of the multiple-module orbiting complex "Mir" and the modernized transport spaceship "Soyuz TM," which were developed on the basis of the latest achievements of Soviet industry, has begun.

Results of research and experiments carried out by crews on board the orbiting complex "Mir" are of great scientific value and will be used in the advancement of basic sciences and in many branches of the economy.

(A photograph is given showing Aleksandrov, Romanenko and Levchenko in their spacesuits after the landing.)

FTD/SNAP 08309

**Cosmonaut Levchenko Pilots TU-154 From
Arkalyk to Moscow After Landing**

18660086 Moscow *TRUD* in Russian 30 Dec 87 p 1

[Article by N. Zheleznov, correspondent (Arkalyk and Baykonur)]

[Excerpt] After the spaceship "Soyuz TM-3" with three cosmonauts on board had completed its last revolution in orbit, several hundred members of the space search service—helicopter pilots, drivers of cross-country vehicles, medical personnel and engineers—became components of a well-coordinated and complex mechanism.

All precautionary measures were taken into account. Despite a heavy blowing snowstorm, vertical visibility was normal, as pilots say.

The snow whirl produced by the reentry vehicle's soft-landing engines had barely subsided when engineers specializing in evacuation of crews rushed to the ship.

All three cosmonauts withstood the landing well. Yu. Romanenko and A. Aleksandrov reached a helicopter with the assistance of physicians, and A. Levchenko walked to the aircraft himself. It would be a short flight for the 46-year-old cosmonaut-researcher, who is a well-known test pilot. We asked him if he could now take over the controls of an airplane.

"Not only take them over, but take off in the airplane," he said.

Half an hour later, a TU-154 airplane took off from the runway of an airfield in Arkalyk and headed for Moscow. A. Levchenko, test-pilot and pilot-cosmonaut, was at the controls of this airplane.

FTD/SNAP 08309

**'Soyuz TM-4' Undocks From 'Kvant' Module,
Redocks at Forward End of 'Mir'**

18660087 Moscow *PRAVDA* in Russian 31 Dec 87 p 1

[TASS Report]

[Text] Flight Control Center, 30 December. The mission of Vladimir Titov and Musa Manarov, who took over space duty on board the scientific research complex "Mir," is continuing.

In line with the designated program of work, the spaceship "Soyuz TM-4" was undocked from the astrophysical module "Kvant" today and docked with the base block on the side of its adapter module. The rearranging of the manned complex was carried out for the purpose of ensuring further transport operations for supplying the complex with fuel and various cargo items, using unmanned transport ships of the "Progress" series.

Before the undocking, the cosmonauts went into the transport spaceship and closed the transfer hatches. The "Soyuz TM-4" ship was separated from the orbiting complex at 1210 hours Moscow time.

On commands from the Flight Control Center, the base block was rotated 180 degrees. The crew then docked the spaceship with the adapter module at 1229 hours.

The onboard systems of the spacecraft functioned normally at all stages of the maneuver.

Vladimir Titov and Musa Manarov are feeling well.

FTD/SNAP 08309

'Mir' Cosmonauts Greet New Year in Orbit

18660083 Moscow IZVESTIYA in Russian 1 Jan 88 p 2

[TASS Report]

[Text] Flight Control Center, 31 December. Soviet cosmonauts Vladimir Titov and Musa Manarov are greeting the year 1988 in orbit. Today the manned complex "Mir" will enter the 'zone of the new year' for the first time at 1457 hours Moscow time. This will happen over New Zealand; at midnight on 1 January Moscow time the cosmonauts will be flying over the area of the Cape of Good Hope.

Today's agenda calls for preparing for operation and switching on a unit called "Elektron," which is intended for replenishing the oxygen in the complex's living compartments; checking radio communication equipment; and taking an inventory of consumable components of the life-support system.

Vladimir Titov and Musa Manarov will rest tomorrow. The families and friends of the cosmonauts will come to the Flight Control Center to send them New Year's greetings. The crew's commander will be 41 on that day.

Both cosmonauts are feeling well.

The flight of the orbiting complex "Mir" is proceeding normally.

FTD/SNAP 08309

Cosmonauts Titov and Manarov Begin Third Week in Orbit

18660089 Moscow PRAVDA in Russian 3 Jan 88 p 2

[TASS Report]

[Text] Flight Control Center, 4 January. The third week of Vladimir Titov's and Musa Manarov's orbital mission has begun.

In accordance with the plan of regular preventive-maintenance work on board the "Mir" complex, the cosmonauts performed routine operations for tending the "Elektron" unit and checked the functioning of a unit of a computer today.

In line with the program of astrophysical research, a series of measurements of flows of high-energy electrons and positrons in near-Earth space has been made with the aid of the "Mariya" apparatus.

In the course of the day, the crew is also to prepare the technological unit "Korund" for operation. This unit is intended for producing semiconductor materials with improved characteristics in conditions of extremely small gravitation.

According to telemetry data and the cosmonauts' reports, the flight of the orbiting complex "Mir" is proceeding normally.

Vladimir Titov and Musa Manarov are feeling well.

FTD/SNAP 08309

Comments on Romanenko's Reaction to Prolonged Flight, Experiments on 'Mir'

Moscow PRAVDA in Russian 14 Dec 87 p 3

[Article by A. Tarasov, special correspondent for Pravda: "Song of the 'Chibis' (Lapwing): Report from the Flight Control Center"; first paragraph appears in italic bold in source]

[Text] I do not know whether this "Lapwing" chirps or whistles when the pressure is pumped out of it, but I do know that to any cosmonaut the name itself of this vacuum suit sounds like a song of the Earth. Because pre-Earth conditioning begins with it. The preparation for landing, for weighted conditions, for home. All I can say is that in their letters to the editor, compassionate earthlings ask, Will these guys really not make it home by the New Year?

Yuriy Romanenko himself has already greeted the New Year in orbit—it was 1978, aboard Salyut-6 with Georgiy Grechko. But the flight then was only 20 days old, and now it is more than 300 days old...Nonetheless, I can reassure you—we will see the likeable faces of the "Taymyrs" [cosmonauts' call-sign] in their native Earth environment around the New Year.

That was the topic of an entire controversy that unfolded at the Flight Control Center, where Viktor Blagov, the deputy flight director, was explaining to journalists the pace and the essence of on-board operations.

It was explained that the crew has been switched to a lighter workload ("like in a hot shop"). The night shifts have been cancelled, the working day has been shortened to four and a half hours (they had started with an eight-hour day or longer), and other exemptions have been introduced...In response to that report comes the question, If we know that the optimum length for an orbital mission is four to six months, why the yearlong circling of the Earth?

Blagov softly answers that a year is hardly enough to take care of business, since the business will not end with circling the Earth. We will not send a man to Mars without a "road test" in weightlessness over the entire length of the flight. Dealing with Mars will take thirty months of flying around our own planet, obtaining all the medical guarantees, and working out all the preventive measures. Of course, the duration of the flight will grow gradually. Romanenko, you could say, has started on that course. Right now, medical and biological studies are profiling him, and medicine has trebled its attention to his every day. The mental support has intensified: music and news are fed on board more often...

The closest observer—the current "Taymyr-2," Aleksandr Aleksandrov—is asked, How does the commander look? Has he changed?

"No, he is normal," testifies the flight engineer.

"His weight is fluctuating within plus or minus half a kilogram," confirms the Flight Control Center, checking the telemetry.

This standard is being maintained with a double dose of physical conditioning. But the difference is still felt: the hands are always overburdened (you could not count the number of nuts and bolts that are screwed and unscrewed, the cargoes that are moved), and the legs are relieved of walking. The muscles of the shin diminished by fifteen percent, other muscles by more or less, and the medical people make comparisons. Romanenko himself chuckles into the microphone: "A dried out Herculesp." And then a comical "designing" of the cosmonaut of the future begins between the spacecraft and the Flight Control Center.

"Bald head, so he does not have to get a haircut..."

"Huge hands..."

"It would be better if he had six!"

"Tiny feet..."

"Or just one, since they are useless..."

"Only with an attachment, so it can be secured..."

"Some American scientist has predicted that the first human will be born in space in 2017," says a Flight Control Center operator, sharing what he has read.

"I do not envy that person," the Taymyrs sympathize beforehand. "He is going to have a hard time on Earth."

Let us see, let us see. Could it really be true that there will be a time when, from a black abyss, people will point to a miniature sky-blue dot and explain to their children: "Look, that is where your grandfather was born. That is Earth..."

They have unburdened their hearts with predictions—and now to work. Work remains the best indicator of disposition and health. Here are some details, simple in appearance, of a dynamic docking-undocking operation that was performed on Mir with Progress-32.

"When docking with cargo vessels, a station does not operate on gyroscopes—it positions itself with attitude-control engines. The procedure uses a lot of fuel," says Viktor Blagov. "Huge masses have to be moved. Our Flight Control Center people are always thinking about how to improve the docking technique, about how to use less fuel. And then, it seems, they came up with something. They fed new calculations into the computer and performed the operation. And in fact, fuel consumption dropped from 190 kilograms to 82 kilograms. Progress-33 docked with the new technique, providing positive confirmation that it works."

And the mirror-beam oven [zerkalno-luchevaya pech] that melted five metallic samples may be considered a model and prototype of a cosmic solar oven. If two halogen lamps operating on a total of 250 watts produced a temperature of 1100 degrees in the focal point of the mirror, then imagine what the Sun would be capable of if it were "bridled" in such a manner. Of course, not inside the station, but in open space, where the oven would require no particular walls, no containers or ampules for the samples...

A curious experiment was able to help measure the distance between Mir's antenna and that of Soyuz TM-3. It was not done with a ruler or in centimeters, but with the radio beam of the "Kurs" system. As it turns out, the system is capable of working not only at tens of kilometers, but also at several meters, with the same "jeweler's precision."

...I hear a well-trained female voice, like those that announce the subway stops.

"Experiment T-12! Three series of jumps on calibrated signals, with three pauses, during which absolute rest will be observed. Then three series of runs with the same sharp pauses..."

A metronome ticks, measuring first twenty jumps and then twenty accelerated running steps, and the cheerful music of the pause plays. This is not some limbering-up: this is an experiment important to designers—an experiment called "Resonance", in which vibrations and loads that travel through the units and structures of the spacecraft as a result of jolts are "caught." With all the cheerfulness of the procedure, I think to myself, these jumps on precise signals in weightlessness, when you are trying to take off, require a special skill.

And everywhere, the question: How are the guys? The replacements have taken off for the cosmodrome. Two crews have been housed in the familiar rooms of the Baykonur hotel for cosmonauts. Now they are already in

the familiar assembly building, and they are taking their places in the Soyuz TM-4...For now, it is prelaunch training, seclusion, "isolation" [obsidka]. The commanders are Vladimir Titov and Aleksandr Volkov; the flight engineers are Musa Manarov and Aleksandr Kaleri; and the cosmonaut-researchers are Anatoliy Levchenko and Aleksandr Shchukin. Our acquaintance with them in space lies ahead, but in the meantime, the replacements are preparing for the journey, as do miners, sailors, and polar expeditioners. All of them are awaited at the end of the long watch by friends who have been doing a good job.

13227

**Results From Supernova Observations Discussed
at Moscow Space Forum**

18660029 Moscow IZVESTIYA in Russian 6 Oct 87 p 3

[Article by B. Kononov and S. Mushkaterov, correspondents]

[Abstract] The article reports on events of the international space forum in Moscow. Conversations with participants of this forum are recorded. A special discussion, "Space and International Relations", and a direct conversation with the crew of the orbiting station "Mir" reportedly took place at the forum, which concluded on 4 October. A special seminar was devoted to results of spacecraft-aided observations of the supernova in the Large Magellanic Cloud. Participants hailed the recent detection of hard X-radiation from this object, using equipment of the space module "Kvant". R. Syunyayev, corresponding member of the USSR Academy of Sciences, related that an international group of which he is a member is now observing X-radiation of a type never before recorded, which is believed to come from the supernova. The observations are being made with the aid of a Soviet instrument called "Pulsar X-1" and an instrument called "Hexe" ("Vedma" ["witch"] in Russian) which was developed in collaboration with West German specialists. FTD/SNAP /9738

Gravity Assist Maneuvers for Solar Probe Missions
18660044 Moscow MOSKOVSKAYA PRAVDA in Russian 14 Nov 87 p 4

[Article by Aleksey Labunskiy, candidate of technical sciences and specialist in the mechanics of space flight: "How Do We Get to the Sun?"]

[Text] The physical processes in the surface regions of our star—what are they? What is the hidden essence of their effect on the weather and climate of the Earth, on our health and how we feel? Finally, by what laws does this giant thermonuclear fusion machine to which all living things on Earth owe their existence operate?

The mission of automatic probes traveling to the nearest environs of that star will help find the answers to these and many other questions. But it is a mission that is not so easy to accomplish...

However surprising it may be, the flight to the Sun, that powerful gravitational "magnet," is one of the most complex missions in cosmonautics. It would seem to be enough just to "brake" the spacecraft to zero velocity in Earth orbit, and the vehicle, "falling" from an altitude of 150 million kilometers (1 A.U.), would take a short cut directly to the Sun.

The energy expense for such a maneuver is so great, however, that, for now, such a flight plan cannot be taken seriously.

In principle, variations of this plan that call for only a partial braking of the vehicle's velocity in Earth orbit are possible. But in these instances, considerable expenses of energy bring only modest results.

Still another route to the Sun is associated with the use of so-called perturbation maneuvers, in which the vehicle uses freely available energy—the gravitational pull of other planets.

The possibilities of perturbation maneuvers were pointed out by the founder of cosmonautics himself, K. E. Tsiolkovskiy. Today, these maneuvers have already found practical application, enabling such projects as the "Grand Tour"—the flight to Jupiter, Saturn, Uranus, and Neptune—and "Vega"—the flight to Halley's Comet.

Including the fly-by of a number of planets in the planned itinerary makes it possible not only to reduce the energy expense, but also to expand considerably the amount of scientific information obtained in the process of carrying out the "solar project." What kinds of variations are there for such itineraries?

We can, for example, use the gravitational field of Venus or Mercury, the planets closest to the Sun. Calculations indicate that a fly-by of Venus on the way to the Sun makes it possible to place the spacecraft at a distance of 0.3 - 0.4 A.U. An orbital period could be chosen for the spacecraft after the Venus fly-by that would bring the craft back to Venus, and the perihelion would be even closer to the Sun. Such an itinerary, lasting 1.5 years, would make it possible to deliver a research probe to within 0.15-0.2 A.U. of the Sun. In flying by Venus, the probe could change the plane of its orbit in order to study the Sun from higher heliographic latitudes.

A flight trajectory near Mercury does not present any substantial advantages for such a mission, because, with its very weak gravitational field, it is not capable of sending a spacecraft very near the Sun in one pass. It would require multiple fly-bys of Mercury (8-10) to get within a distance of 0.2-0.25 A.U. of the Sun.

Quite tempting, but complex, are itineraries that use the Earth's gravitational field. In order to make multiple approaches of the Earth, thereby achieving the perturbation effect, a spacecraft would have to first fly by Mars or Venus (or execute an equivalent impulse maneuver with its engine). Analysis shows that, of these variations, an Earth-Venus-Earth-Sun itinerary would be the most efficient. After the launch from Earth, the fly-by of Venus, and the return to Earth a year after the launch, the spacecraft could use the Earth's gravitational field to move into a flight trajectory to the Sun with a perihelion of 0.25-0.3 A.U. The amount of fuel expended would be comparable to that expended if the craft flew directly to Venus.

Numerical data indicate that the planet Jupiter offers the best possibilities for organizing an itinerary to our star. With Jupiter, a probe could be delivered to environs truly near the Sun—to within less than 0.1 A.U. And an even closer approach could be achieved if the craft's initial departure speed from Earth were increased.

With its powerful gravitational field, Jupiter is capable of throwing a spacecraft into a flight trajectory from which it would be possible to fly over the polar regions of the Sun (something scientists have long dreamed of). It is important that on such a flight the scientific targets would be the two largest bodies in the solar system and the broadest expanse of interplanetary space outside the plane of the ecliptic.

The duration of such a mission is quite acceptable: 2.5 to 3 years.

And so, however paradoxical it may be, the most efficient of all ways is to initially go away from the center of the solar system so that then, returning, we can go right up that blazing glow, that mystery-filled region.

What would such an odyssey take in terms of energy? No more than a flight to Jupiter. However, it is possible to save here. To do this, we can use the energy of the Earth's gravitational field a second time on the way to Jupiter if we first fly by either Venus or Mars. Of course, the duration of the mission would increase considerably.

If saving energy is of paramount importance, then the most efficient itinerary is an Earth-Venus-Earth-Jupiter-Sun route. Preserving all the merits of flights via Jupiter, such a route makes it possible to reduce fuel consumption by almost a third. Favorable launch windows for this most "miserly" itinerary occur approximately every 3.5 years.

Such is the whim of nature: it turns out to be easier for earthlings to send spacecraft to reaches of the solar system that are many billions of kilometers away than it is to propel them hundreds of millions of kilometers in the direction of the blazing giant that is "nearby."

13227

UDC 650.388.2

Charged Particle Fluxes on Artificial Earth Satellite Trajectories

18660114p Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 3,
May-Jun 87 (manuscript received 14 Nov 85)
pp 473-475

[Article by I.V. Getselev, G.A. Timofeyev, Yu.I. Gubar,
V.A. Kuznetsova and A.R. Mozhukhina]

[Abstract] A probabilistic method was used in describing a satellite trajectory which involves finding of the probability m_{ij} of presence of a satellite in elementary cells t_{ij}

into which L.B space is broken down. The probability m_{ij} is found as the ratio of the time t_{ij} of satellite presence in the cell to the total flight time t_{total} . Experimental data on charged particle fluxes are also represented in L,B coordinates. Then the known radiation intensity I_{ij} in a cell t_{ij} of L,B space is used to find the mean intensity on the satellite trajectory. The energies for which the spatial-energy distributions of charged particles are found are determined in accordance with the thicknesses of the shielding. The method is very economical and the average computation time for a broad set of shieldings does not exceed 10 minutes. The computations can be made in advance, prior to satellite flight. The distributions of intensity of charged particles can be corrected if there are changes in their spatial-energy distribution. Proton and electron fluxes under aluminum shieldings of various thicknesses were computed for about 1000 orbits. A table gives the fluxes in a number of orbits under various shieldings with a thickness of 0.5 g/cm² corresponding to proton energies E_p greater than 20 MeV and electrons E_e greater than 1 MeV penetrating through this shielding. The influence of various orbital parameters is considered for satellites with circular orbits situated much of the time below the radiation belts, satellites with circular orbits passing through the maximum of the inner radiation belt, satellites with circular orbits passing through the maximum of the outer belt, satellites with elliptical orbits passing through the outer radiation belt and the maximum of the inner belt and satellites with greatly elongated elliptical orbits. Computations of charged particle fluxes in satellite orbits given in the article can be used in planning satellite flights. References 4: 3 Russian, 1 Western.

5303/08309

UDC 535.24:523.42

Application of Statistical Regularization Method to Nonlinear Thermal Sounding Problem With Limited A Priori Information

18660114k Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 3,
May-Jun 87 (manuscript received 20 Feb 87)
pp 439-447

[Article by Yu. Gyuldner and Ye.A. Ustinov]

[Abstract] The statistical regularization method was applied to the nonlinear thermal sounding problem. It is shown that the application of a priori correlation matrices based on an analysis of real a priori information is not a necessary condition. Such a priori correlation matrices can be replaced by model correlation matrices determined on the basis of the kernel of the linearized integral equation of the problem. Closeness of the initial approximation to the sought-for solution is also not a necessary condition. Use of the Kantorovich-Newton method makes possible effective solution of the initial nonlinear integral equation, eliminating the requirement for correctness of the linear approximation. Application of the described nonlinear statistical regularization

method to interpretation of measurements with the Fourier spectrometer on the "Venera-15" and "Venera-16" demonstrated its applicability for thermal sounding (D. Spankuch, et al., *KOSMICH. ISSLED.*, Vol 23, No 2, pp 206-220, 1985). However, it has a broader field of applications for problems in which nonlinearity of the inverse problem is important. Yu.M. Timofeyev, et al. (*METEOROLOGIYA I GIDROLOGIYA*, No 8, pp 66-73, 1986) used an iteration scheme and the statistical regularization method in model correlation matrices applicable to the retrieval of vertical profiles of trace gas components and aerosol using data from eclipse sounding from a satellite. Retention of the advantages of the ordinary, linear statistical regularization method in many cases is preferable to other methods for solving nonlinear inverse problems (such as with the relaxation method). Figures 3; references 16: 13 Russian, 3 Western.

5303/08309

Stationary State of Electron Beam Artificially Injected Into Ionospheric Plasma

18660071a Moscow GEOMAGNETIZM I
AERONOMIYA in Russian Vol 27, No 6, Nov-Dec 87
(manuscript received 15 Sep 86) pp 961-964

[Article by G. V. Lizunov and A. A. Silivra, Kiev State University]

[Abstract] The dynamics of an electron beam injected along the magnetic field was investigated theoretically after an equilibrium distribution of plasma electrons had been established. Computations were made of the configuration, internal structure and dynamics of the beam applicable to conditions of active plasma experiments in the ionosphere. The influence of plasma with a finite temperature on the stationary state of a beam injected into the ionosphere can be represented qualitatively as follows. In the immediate neighborhood of the injector the beam density is much greater than the density of the background plasma and as a result the redistribution of plasma electrons does not essentially change the electrostatic field within the beam. After emergence from the injector the beam begins to expand, but since the maximum radius of expansion is largely determined by the energy of the beam electrostatic field, its radius differs little from the case of beam expansion in a vacuum. In this stage, beam density becomes considerably less than the plasma density and the screening influence of the latter is great. However, this has little influence on the motion of beam electrons because in this stage the determining force is from the direction of the geomagnetic field and compresses the electron beam approximately to the initial radius. Weak effects from the plasma direction, leading to mixing of individual electron trajectories and evening out of the beam boundary, are accumulated only after a great number of periods have elapsed. References 6: 4 Russian, 2 Western.

5303

Mean Statistical Structure of Magnetospheric Tail Determined From Satellite Data

18640071b Moscow GEOMAGNETIZM I
AERONOMIYA in Russian Vol 27, No 6, Nov-Dec 87
(manuscript received 8 Sep 86) pp 987-993

[Article by N. A. Tsyganenko, Physics Institute, Leningrad State University]

[Abstract] Quantitative models of geomagnetic field distribution were constructed for the entire prelunar region of the tail of the magnetosphere on the basis of several series of satellite observations (1966-1980, 1969-1974). These models provided information on high-latitude parts of the tail to distances of about 30 RE. The great volume of analyzed data made it possible to take into account the dependence of the structure of the tail field on inclination of the geodipole and to break down the total volume of data into a number of samples for intervals of the Kp index, interplanetary magnetic field components, solar wind density and some other parameters for the purpose of study of tail structure as a function of terrestrial disturbance and some geoeffective parameters of the interplanetary medium. The model computations involved 18 independent parameters (coefficients A1-A18 and 2 nonlinear parameters (radius of oscillations and sheet half-thickness). A table gives the values of model parameters of the geomagnetic tail for 7 different variants of experimental samples. Figure 1 gives the distribution of the total Bx field component over the tail current sheet for the mentioned 7 variants; Fig. 2 shows the distribution of the total Bx component along the axis of the magnetospheric tail for the same variants; Fig. 3 shows the position of the plane of the tail current sheet for different directions of the interplanetary magnetic field y-component. The data confirmed the hypothesis of twisting of the plasma sheet about the axis of the tail in a direction determined by the sign on the By component of the interplanetary magnetic field. Information was obtained on penetration of the By component into the region of the plasma sheet and tail. Figures 3; references 10: 4 Russian, 6 Western.

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Angle of Attack of Tail Magnetopause Determined From Magnetic Measurements on 'Prognoz-7' in Initial Substorm Phase

18660071c Moscow GEOMAGNETIZM I
AERONOMIYA in Russian Vol 27, No 6,
Nov-Dec 87 (manuscript received 5 Jan 87)
pp 1033-1035 [Article by K. G. Ivanov and V. A. Siyazhkin, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] The "Prognoz-7" satellite intersected the magnetopause in the frontal part of the magnetospheric tail in the initial phase of a substorm on 22 March 1979. The magnetopause was a strong discontinuity oriented at a very great angle of attack (over 35°) to the solar wind. The observations experimentally confirmed the hypothesis that in the initial phase of a substorm there is an

increase in the dynamic head on the tail of the magnetosphere due to an increase in the angle of attack caused by shifting of the magnetic flux from the daytime to the nighttime side. The angle of attack is an important parameter because it essentially determines the degree and dynamics of tail detachment which attain critical values in the substorm explosive phase. An analysis revealed that in the considered case there was a considerable increase in the angle of attack in the initial

substorm phase in comparison with the quiet magnetosphere, during this phase increasing from the background 20° to $25-30^\circ$ at -5 to -25 RE and reaching a critical level ensuring detachment of part of the tail and development of the explosive phase. Figure 1; references 10: 4 Russian, 6 Western.

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**'Vega-1' and 'Vega-2' Automatic Stations.
Functioning of Landing Modules in Venusian
Atmosphere**

18640065a Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 4 Jun 86) pp 649-654

[Article by V. A. Deryugin, V. P. Dolgoplov, V. P. Karyagin, V. M. Kovtunenkov, R. S. Kremnev, K. M. Pichkhadze, G. N. Rogovskiy and R. Z. Sagdeyev]

[Abstract] The "Vega-1" and "Vega-2" automatic interplanetary stations were launched on 15 and 21 December 1984 for research on the Venusian atmosphere and surface, Halley's comet, and in space along the course of their flight trajectories. The two vehicles flew by the nucleus of Halley's comet at distances of 8912 and 8036 km, conducting research from those distances. These observational data were used for more precise guidance of "Giotto" to the comet. The "Vega" craft represented a further development of the "Venera" vehicles and consisted of flyby and landing modules. A new self-guiding rotating platform was incorporated with a television system and instrumentation for ensuring constant observation of the comet on the approach segment. The systems and instruments were safeguarded from the damaging effect of coma particles, having a relative velocity of motion of about 80 km/s, by two- and three-layer protective panels of alloys. During the time of the Halley flyby the rate of data transmission was increased by a factor of 20. The area of the solar cells was doubled. A gyroscopic stabilization system was introduced should the optical orientation systems fail due to luminescence of coma dust particles. The "Vega-1" reached Venus on 11 June 1985 and the "Vega-2" on 15 June. The descent of the landing modules required 63 and 61 minutes, respectively. During descent into the atmosphere, balloons were released which made investigations of the Venusian cloud layer independently of the descent module. The landing modules made determinations of the elemental composition of the ground, temperature, pressure, physical and optical properties of the atmosphere, cloud structure and composition. The vehicles landed in different geological regions about 1600 km from one another at elevations of 0.7 and 0.5 km; the temperatures and pressures at these points did not differ greatly. Figures 3.

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**'Vega-1' and 'Vega-2' Automatic Stations:
Functioning of Flyby Vehicles During Encounter
With Halley's Comet**

18660065b Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 11 Jun 87) pp 655-658

[Article by V. P. Dolgoplov, V. P. Karyagin, V. M. Kovtunenkov, R. S. Kremnev, O. V. Papkov, K. M. Pichkhadze, G. N. Rogovskiy, R. Z. Sagdeyev and K. G. Sukhanov]

[Abstract] The "Vega-1" and "Vega-2" stations made their principal observations of the coma and nucleus of Halley's comet on 6 and 9 March 1986; the closest distances to pericenter were 8912 and 8036 km, respectively. The position of the "Vega" vehicles was determined not only by traditional measurements of range and radial velocity, but also using interferometer measurements which gave the angular position between the vehicles and quasars emitting at 18 cm (these measurements were made at Goldstone, Madrid and Canberra). Figure 1 is a diagram of the station. The stations passed within the cometary nucleus and experienced the effect of cometary dust particles, but orientation was not lost and all systems remained operable. As a result of bombardment by dust particles the panels of solar cells lost 45% of their electric power, but the remaining power was adequate for all needs. The automatically stabilized platform also experienced severe bombardment but did not lose orientation on the nucleus and was able to obtain high-quality optical data and TV images. One of the main objectives of the research was to supply needed data for the "Giotto" mission. Prior to the "Vega" experiment the accuracy in determining the position of the comet was only 1500 km, which was entirely inadequate for guidance of the "Giotto," which had to flyby the comet at a distance of about 500 km. The "Vega" television cameras made possible a precise registry of the position of the cometary nucleus within its coma. Late in 1986 and in early 1987 the stations, after looping around the sun, passed through the cometary tail and conducted research on the substances remaining in the tail.

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**Thermal Structure of Venusian Atmosphere
Determined From Results of Measurements From
'Vega-2' Landing Module**

18660065c Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 659-672

[Article by V. M. Linkin, G. Blamont, S. I. Devyatkin, S. P. Ignatova, V. V. Kerzhanovich, A. N. Lipatov, K. Malik, B. I. Stadnyk, Ya. V. Sanotskiy, P. G. Stolyarchuk, A. V. Terterashvili, G. A. Frank and L. I. Khluyustova]

[Abstract] The "Meteo" experiment was carried out by the "Vega-2" landing module. It involved research on the thermal structure of the Venusian atmosphere. The main thermodynamic parameters were measured using four temperature and three pressure transducers (all of which are described in detail). Temperature and pressure were measured on the entire descent segment in the atmosphere and after landing on its surface. These results were used in computing the dependence between the altitude of the landing module above the surface on the assumption of hydrostatic equilibrium. A correction was introduced for the nonidealness of the equation of state for carbon dioxide, the main atmospheric component, and for the dependence of gravity on altitude.

Hydrostatic and aerodynamic descent models were compared. The measurements began at an altitude 63.6 km. Surface temperature was about 733 K and pressure was about 89.3 bar. The landing elevation was about 500 m. Since there was a high rate of interrogation of the transducers and good vertical resolution (about 15 m on the upper segment and about 5 m at lower altitudes) the results can be considered the vertical profile of static stability, the difference between the measured vertical temperature gradient and the adiabatic gradient. Unstable stratification was observed in the lower 5 km. Instability decreases in the layer occurring several hundreds of meters above the surface. The presence of stationary unstable stratification above the surface is difficult to explain. It can be postulated that the observed unstable stratification in the lower five kilometers is either a nonstationary formation or is maintained by some unknown dynamic factors. The "Meteo" experiment was carried out jointly by the USSR Space Research Institute, Scientific Research Center imeni Babakin and the French Aeronomy Service. Figures 7; references 5: 2 Russian, 3 Western.

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Research on Absorption of UV Radiation in Venusian Atmosphere From 'Vega-1' and 'Vega-2' Landing Modules

18660065f Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 6 Sep-Oct 87
(manuscript received 8 Jun 87) pp 591-706

[Article by Zh. L. Berto, A. P. Ekonomov, B. Mez, V. I. Moroz, A. Aberzhal, V. I. Gnedykh, A. V. Grigoryev, B. Ye. Moshkin, A. Oshkorn, Zh. P. Pommero and S. B. Serge, eval]

[Abstract] The described experiment was for determining the vertical distribution of atmospheric gases exhibiting strong absorption in the UV spectral region (2200-4000 Å). The "Vega-1" and "Vega-2" landing modules for this purpose carried an instrument consisting of an artificial source of UV radiation, cells through which atmospheric gas was passed and a spectrometer for measuring the spectrum of radiation passing through the cell. The objective of the research was a determination of the chemical composition of the Venusian atmosphere and the chemical processes transpiring there and identification of the so-called "UV absorber," the substance or group of substances responsible for drop-off of the albedo of single scattering with wavelength at different altitudes. The landing modules landed on the nighttime side, dictating use of the artificial source, a method used on landing modules for the first time. Its advantage is the possibility of work at shorter wavelengths where the anticipated absorption is great, but the method has lesser response. The ISAV-C instrument used in this work is described (Fig. 1 is an optical diagram with 17 components identified and Fig. 2 is a diagram of instrument placement on the landing module). The heat regulation

system, data processing system, operational mode, calibration procedures and method for identifying absorbing gases are discussed. These measurements, in the range 230-400 nm, revealed a broad absorption band, without a fine structure, in the short-wave part of the working range. The dependence of absorption on wavelength and its vertical variation suggest that the main absorbers are SO₂ and elemental sulfur. The quantitative estimates made on this assumption give SO₂ quantities close to those generally accepted, whereas for vapors of elemental sulfur the content is considerably greater than that adopted on the basis of geochemical models. Figures 10; references 14: 9 Russian, 5 Western.

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Vertical Structure of Venusian Cloud Layer at Landing Sites of 'Vega-1' and 'Vega-2' Vehicles

18660065g Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 707-714

[Article by V. I. Gnedykh, L. V. Zasova, V. I. Moroz, B. Ye. Moshkin and A. P. Ekonomov]

[Abstract] The objective of the "Vega" experiment was a study of parameters of aerosols in the Venusian atmosphere (particle size distribution and concentration of aerosols, shape of particles and refractive index of their material). "Pioneer-Venus" data seemed to indicate that the main cloud layer consists of three types of particles forming three modes, the modal diameter of the third type being about 7.3µ, aspherical particles of unknown composition. Doubts have been expressed that this third mode actually exists, but this could be checked only by an independent experiment. The instrument used on the "Vega" vehicles was the ISAV-A aerosol spectrometer. The ISAV-A consists of two functional modules: aerosol photoelectric spectrometer and backscattering sensor. The operating principle is based on measurement of the light fluxes scattered in four directions (forward, backward, to the right and left) by individual aerosol particles passing through the instrument (Fig. 1 illustrates the optical system, with 33 components identified, serving as a basis for the description of instrument operation). The range of aerosol particles can in actuality be represented by two modes: the first mode is described by a Junge distribution from 0.5 to 5µ and the second mode consists of particles measuring 2-5µ. Particles of the second mode are spherical. The concentration of second mode particles changes sharply in the altitude range 45-50 km, whereas the concentration of first mode particles changes smoothly in the altitude range 35-55 km without forming clearly defined cloud layers. A submicron aerosol having a mass density 0.1-2 mg x m⁻³ is present at altitudes 30-60 km. A nighttime glow caused by the hot planetary surface is observed in the Venusian atmosphere at a wavelength of about 1µ. Figures 4; references 13: 9 Russian, 4 Western.

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Gas-Chromatographic Analysis of Products of Thermal Reactions of Aerosol in Venusian Cloud Layer on 'Vega-1' and 'Vega-2' Automatic Interplanetary Stations

18660065h Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 715-720

[Article by N. V. Porshnev, L. M. Mukhin, B. G. Gelman, D. F. Nenarokov, V. A. Rotin, A. V. Dyachkov and V. B. Bondarev]

[Abstract] The first direct contact measurements of sulfuric acid in the Venusian atmosphere were made during the "Vega" experiment. Both "Vega" descent modules carried the "Sigma-3" chromatograph. The article gives the results of data processing, model and calibration experiments and particular attention is given to the design and capabilities of the instrumentation employed. The chromatograph and auxiliary modules were placed outside the instrument compartment in a sealed, heat-insulated capsule. The shielding was adequate for normal instrument operation with an external pressure of 0.1-25 atm and an ambient temperature from -20 to +320° C. A new chromatograph component was a block of three reaction cells (Fig. 1 is a diagram of such a cell) for the accumulation and transformation of H₂SO₄ by means of the selective reaction $C + H_2SO_4$ into the components CO₂, H₂O and SO₂, which were investigated chromatographically. A number of chromatograms are illustrated and discussed. The following components were identified: CO₂, H₂, COS, H₂O and SO₂. It was found that in the altitude range 61.5-54 km in the "Vega-1" descent region the H₂SO₄ aerosol concentration is much less than 1 mg/m³, although its detection is possibly complicated by the presence of compounds containing chlorine. At altitudes 61.5-48 km the mean concentration is 1.0 plus or minus 0.2 mg/m³, in the "Vega-2" descent region at altitudes 61.5-54 km the concentration is 0.6 plus or minus 0.1 mg/m³. In the case of presence of sulfur the lower limit of H₂SO₄ content is 0.4 plus or minus 0.1 mg/m³. The predicted estimate for sulfur aerosol is not less than 0.1 mg/m³. Figures 2; references 10: 7 Russian, 3 Western.

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Roentgenoradiometric Analysis of Aerosol in Venusian Clouds by 'Vega-1' and 'Vega-2' Automatic Interplanetary Stations

18660065i Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 721-736

[Article by B. M. Andreychikov, I. K. Akhmetshin, B. N. Korchuganov, L. M. Mukhin, B. I. Ogorodnikov, I. V. Petryanov and B. I. Skitovich]

[Abstract] Sulfuric acid is present in the aerosol of Venusian clouds, but is not its main component. Aerosolic sulfur may be present, but much has remained

unclear concerning the elemental composition of cloud aerosol. The "Vega-1"-"Vega-2" experiment yielded the first information on the vertical distribution of chemical elements in cloud aerosol and their content. The two "Vega" descent modules carried IPF roentgenoradiometric instruments, one of whose purposes was a determination of the phase transitions of aerosol matter. The roentgenoradiometric method makes it possible to study a sample without destroying or modifying it. The design and operating principle of the IPF are described (Fig. 1 in the text is a diagram of its analytical module) and calibration procedures are outlined. Analysis of the collected data revealed that the principal chemical elements of aerosol are chlorine, sulfur, phosphorus and lighter elements. The profile of the elemental composition of cloud aerosol was obtained in the altitude range 61-47 km. Phosphorus was discovered in the aerosol of Venusian clouds for the first time. In the planetary clouds there are three levels of distribution of chemical elements in aerosol. The upper level (61-53 km) consists of a series of alternating layers of aerosol containing sulfur, possibly sulfuric acid. The middle, transitional layer (52-53 km), consists of a sequence of three aerosol layers containing chlorine and sulfur with a high mass load. The lower level (52-47 km) is the most saturated with aerosol, primarily containing phosphorus, alternating with aerosol containing sulfur. Mass load profiles of phosphorus, sulfur and chlorine in aerosol were constructed. In general, the structures of the clouds in the region of parachuting of the two landing modules were similar. Figures 12, references 17: 8 Russian, 9 Western.

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Chemical Composition and Structure of Venusian Clouds Determined From Results of Roentgenoradiometric Experiments Carried Out by Landing Modules of 'Vega-1' and 'Vega-2' Automatic Interplanetary Stations

18660065j Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 737-743

[Article by B. M. Andreychikov]

[Abstract] In the range of measurements made with the roentgenometric apparatus on the "Vega-1" and "Vega-2" the cloud aerosol in the altitude range 62-51.5 km consists for the most part of compounds containing sulfur and chlorine. The altitude range 51.5-47 km is the region of occurrence of aerosol containing phosphorus (with a maximal content about 33 mg/m³) and sulfur (maximal content about 13 mg/m³). The Venusian atmosphere may contain phosphorus oxides which are the products of hypergenesis and possibly volcanic activity. The active participation of phosphorus oxides in redox processes forms the profile of water vapor, carbon monoxide and atmospheric components containing sulfur. The formation of an aerosol layer with an orthorhombic form of P₂O₅ may occur at an altitude of 12-13 km. A

layered structure of aerosols of phosphoric acids, alternating with aerosol of elemental sulfur, is formed on the nighttime side at 46.5 - 51.5 km. The layer of aerosol containing chlorine is at 52.3 - 56.5 km. The upper cloud layer consists of alternating layers of aerosol containing sulfur and chlorine. The aerosol containing sulfur is largely sulfuric acid with an admixture of sulfur. On the daytime side of the planet, as a result of interaction of the products of photochemical processes between phosphene and chlorine and phosphorus oxides the layer of phosphoric acids is modified and may even disappear. With maximal production of sulfuric acid in photochemical processes the aerosol of clouds may for the most part consist of various forms of sulfur, especially sulfuric acid. The sulfuric acid in the upper layers on the nighttime side is a product of transport from the daytime side. Thunderstorm activity may occur due to the presence of layers of different chemical composition in these clouds. Figure 1; references 10: 7 Russian, 3 Western.

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Determining Chemical Composition of Aerosol in Venusian Cloud Layer on 'Vega-1' Automatic Interplanetary Station Using 'Malakhit' Mass Spectrum Analyzer

18660065k Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 26 Jun 87) pp 744-750

[Article by Yu. A. Surkov, V. F. Ivanova, A. N. Pudov, E. P. Sheretov, B. I. Kolotilin, M. P. Safonov, R. Toma, G. Izrael, Zh. Lespanol, D. Imbo, A. Ozer and D. Karamel]

[Abstract] The "Malakhit" instrument (devised under the Soviet-French cooperation program) was carried aboard the "Vega-1" for collection of more precise information concerning the chemical composition of the aerosol fraction of the Venusian cloud layer. The instrument consists of two independent modules: the collector-pyrolysis system for the collection and processing of the aerosol fraction of clouds and a mass spectrometer for analysis of the atmosphere or the gaseous products of the pyrolytic decomposition of aerosol. Figure 1 is a diagram of this instrument. Details are given on its principal components (collector-pyrolysis system, mass spectrometer, vacuum magneto-ionization pump, gas intake system, aerosol intake system and electronic system). Among the technical specifications of the instrument are the following: range of registered masses — 12-150 amu; dynamic range — not less than 10^3 ; time required for scanning mass spectrum — 50 s; quantity of aerosol collected on filter during one sampling — 50-500 mg (depending on sulfuric acid content in clouds); temperature of heating in pyrolysis furnaces — 400°C; response for sulfuric acid aerosol — 2.2×10^{-2} mg/m³; power consumption — 130 W (maximum); weight — 17.5 kg). Instrument operation aboard the station is described and the work program is outlined in a table. For the first time experimental confirmation of the sulfuric acid nature of the clouds was obtained. The limits of sulfuric acid

content were computed using the registered mass spectra and the spectra of calibration mixtures. The lower limit was estimated at 2 mg/m³ and the upper limit at 10 mg/m³. The lower limit of chlorine content was 0.3 mg/m³, confirming earlier data. Unfortunately, not all the possibilities of the instrument could be realized due to noise arising in the instrument during descent; no precise quantitative estimate of sulfuric acid could be made and no reliable determination of the composition of the fine fraction of aerosol or the form of chlorine present was possible. Figures 3; references 14: 11 Russian, 3 Western.

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Elemental Composition of Venusian Rocks in Northeastern Part of Terra Aphrodite (Determined Using Data From 'Vega-2' Landing Module)

18660065l Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 31 Jul 86) pp 751-761

[Article by Yu. A. Surkov, L. P. Moskaleva, V. P. Kharyukova, A. D. Dudin, G. G. Smirnov, S. Ye. Zaytseva, A. N. Tikhomirov and O. S. Manvelyan]

[Abstract] One of the main objectives of the "Vega-2" landing module was a determination of the composition of Venusian rocks in a new geomorphological province of Venus using the roentgenoradiometric method used earlier by the "Venera" spacecraft. The landing region was in the northeastern part of Terra Aphrodite. Unlike similar determinations made earlier, the topography was a typical region of gradual transition from hilly plains to high mountains. The landing site was near a mountain with an elevation of 3.4 km. Reflectivity in the area was close to the average for the planet and corresponded to a rocky surface with a small covering of fine-grained material. The landing site was at 1.8 km above the mean surface where temperature and pressure were 462°C and 90 bar. The collected data have greatly broadened ideas concerning the types of rocks making up the Venusian surface. The concentrations of the principal rock-forming elements from Mg to Fe and some heavier rare elements were determined. The method was essentially the same used earlier for such research on the Moon, Mars and Venus. Figure 1 is a diagram of the instrument used. It consists of two modules: a detection module and a multichannel pulse analyzer module, both of which were situated within a pressurized-thermostated compartment. The preflight preparation of the experiment is described in detail (method for processing spectra, choice of rocks to be investigated, analysis of scattering spectra in empty ground receiver, correction for decay of radioisotopic sources and pressure change in analytical cell). The instrument was activated at an altitude of 23 km above the surface and for 35 minutes registered background spectra used for spectrometer calibration. The ground sampler began operation upon landing. A block diagram illustrates the successive steps in analysis of these spectra. A table gives measurement data from

the "Vega-2" in comparison with determinations made in other geomorphological regions. Analysis of ground spectra in the energy range above 5.9 keV made it possible to estimate the upper limits of content of elements with Z greater than 26. No statistically significant results were obtained in the energy region 7-20 keV and therefore for concentrations of elements heavier than Fe only the upper limits could be obtained: Cu less than 0.3 percent; Zn less than 0.2 percent; As, Se, Br less than 0.08 percent; Sr, Y, Zr, Nb, Mo less than 0.1 percent; Pb less than 0.3 percent. With respect to the content of the main rock-forming elements the ground at the "Vega-2" landing site is comparable to terrestrial gabbroids of normal alkalinity. Using the terrestrial petrographic classification it can be regarded as olivine gabbro-norite. Figures 5; references 3; 4 Russian, 1 Western.

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Content of Natural Radioactive Elements in Venusian Rocks Determined Using Data From 'Vega-1' and 'Vega-2' Stations

18660065m Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 4 Feb 87) pp 762-767

[Article by Yu. A. Surkov, F. F. Kirnozov, V. N. Glazov, A. G. Dunchenko and L. P. Tatsiy]

[Abstract] The "Vega-1" and "Vega-2" descent modules carried gamma spectrometers for measuring the content of natural radioactive elements in Venusian rocks. The instrument consists of two parts: detection module and a module for data processing and output. Both modules were placed within the pressurized and thermostated descent module compartment. A block diagram is shown and the operating principle is described. The instrument registered gamma radiation in the energy range from 0.3 to 3.0 MeV. The weights of the two modules were 4.0 and 3.5 kg and power consumption was 5.0 and 5.4 va. The spectrometers were activated at an altitude of about 25 km above the surface and functioned cyclically and continuously until the instrument ceased to operate. Each such cycle lasted 200 s (190 s for data collection and 10 s for its output). The "Vega-1" registered nine spectra before landing and eight after landing, whereas the "Vega-2" registered ten before landing and nine after landing. Tests of analogues of the gamma spectrometers were carried out on the earth in areas of magmatic rocks with a known mineral composition, especially with known uranium, thorium and potassium contents. At the surface the gamma spectrometer detector was situated about 50 cm above the investigated rock. It was found that 90 percent of the gamma radiation enters the detector from rocks situated within a circle with a diameter of 4-4.5 m. A table gives the results of these determinations, together with data collected earlier. The measurement data for the two sites were quite close with relatively low contents of natural radioactive elements. The abundant data available on the distribution of

uranium, thorium and potassium in the main families of terrestrial magmatic rocks made it possible to ascertain the approximate petrochemical composition of Venusian rocks on the basis of their content of natural radioactive elements. The Venusian rocks appear to be analogues of terrestrial gabbroids and tholeiitic basalts. These data make possible increased understanding of Venusian geological structure and a comparison of these findings with the history of development and present-day structure of the Earth. Figures 4; references: 7 Russian.

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Some Periodicities in Motion of Halley's Comet Relative to Center of Mass

18660065n Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 25 Jun 87) pp 768-780

[Article by V. A. Sarychev, V. V. Sazonov, V. V. Savchenko and V. I. Tarnopolskiy]

[Abstract] The periodicities in three series of surface observations of Halley's comet were investigated. The first series consisted of measurements of its brightness in January-February 1984, whereas the two other series consisted of observations of cometary right ascension and declination in September 1985-February 1986. Harmonic analysis methods were used in detecting the periodic components of these series. The first series exhibited a component with a period 2.36 plus or minus 0.084 days (56.6 plus or minus 2 hours), attributable to the proper rotation of the cometary nucleus. In certain segments of the second and third series, components with periods 10.0 plus or minus 2.3 days and 9.1 plus or minus 2 days, respectively, were detected. The periods of some components of the first and third series virtually coincide. A number of possible explanations of this result are proposed and the results of detailed processing of these series are outlined. Figures 5; references 12; 9 Russian, 3 Western.

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Results of Infrared Spectrometer Experiment. 1. Infrared Radiation of Parent Molecules in Halley's Comet

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ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 781-792

[Article by V. I. Moroz, M. Combes, A. V. Grigoryev, J. F. Crifo, T. Encrenaz, J. Crovisier, J. P. Bibring, N. F. Sankov, N. Koron, D. Bockelee-Morvan, Yu. V. Nikolskiy, R. Gispert, J. M. Lamarre, V. A. Krasnopolskiy, C. Emerich, R. Rokar and T. Owen]

[Abstract] The "Infrared Spectrometer" experiment was for solving two problems: registry of IR emissions of parent molecules in the coma surrounding the nucleus

and research on the IR emission of the nucleus. The first part of the research, on parent molecules, is examined in this article; a second article, devoted to the nucleus, is contained in the same number of the journal (p 793 ff). The experiment was carried out as a joint French-Soviet space project. The instrument itself was developed, fabricated and calibrated in France with the participation of Soviet specialists. Data processing and interpretation are continuing in both countries; the article summarizes the results obtained as of May 1987. A diagram of the optical system is given and serves as a basis for discussing its operation. The technical specifications of the IR spectrometer include: weight 18 kg; size 990 x 280 x 240 mm; power use during measurements 18 W; power use during standby 4 W; long-wave spectral channel 6-12 μ ; short-wave spectral channel 2.3-4.9 μ ; radiometric channel 7-14 μ ; diameter of primary telescope mirror 140 mm; diameter of secondary mirror 56 mm; equivalent focal length 56 mm; material of optical elements: Ge; material of radiation detectors: CdHgTe and InSb; cryogenic system: liquid nitrogen. On the day of maximal approach, spectra of the inner coma were registered in two wavelength regions, but only one (2.3-3.5 μ) was used in this study. The procedures for processing the measurement data are described. Three cometary emissions were detected which are interpreted as H₂O molecules, CO₂ and a superpositioning of vibrations of C-H bonds in hydrocarbons (bands 2.66, 4.26 and 3.35 μ). This was the first time that carbon dioxide was directly demonstrated in comets. The flux of CO₂ molecules from the comet is 2 plus or minus 0.6 x 10²⁸. Characteristic vibrations of C-H bonds in hydrocarbons at 3.35 μ were discovered for the first time in cometary spectra. The flux of water molecules from the cometary nucleus was 1.6 plus or minus 0.2 x 10³⁰ s⁻¹. Figures 10; references 31: 9 Russian, 22 Western.

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Results of Infrared Spectrometer Experiment. 2. Infrared Radiometry of Nucleus of Halley's Comet
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ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 793-809

[Article by Yu. V. Nikolskiy, C. Emerich, J. M. Lamarre, N. F. Sanko, M. Combes, V. I. Moroz, J. Crovisier, T. Encrenaz, F. Rokaer, A. V. Grigoryev, R. Gispert, J. P. Bibring, A. V. Kiselev and N. Koron]

[Abstract] This is the second article on the results of the "Infrared Spectrometer" experiment in this issue of the journal; the first part (p 781 ff) dealt with the parent molecules, whereas the current article is devoted to IR radiometry of the nucleus. Since the data processing is still continuing, the article gives the results obtained as of May 1987. The experiment was carried out only on the "Vega-1." The instrument was mounted on a platform which by means of a TV system directed the optical instruments on the center of cometary brightness. It was assumed that the brightness center coincides with the

nucleus. The instrument has a two-mirror telescope which is described with emphasis on the modulation grid of the radiometric channel, intended for discriminating emission from the nucleus. During the flyby the minimal distance to the nucleus was 8890 km; the maximal distance from which observations were made was 45,000 km, during which the phase angle changed. A total of 128 measurements were made in each quadrant (each 18 s). The dependence of the output signal on time, measured in all four quadrants during flyby through the cometary coma, was determined. Such data were used for obtaining information of two types: color temperature and brightness temperature and their spatial distribution. The color temperature was T equals 420 plus or minus 60 K. It was found that the brightness temperature at the hottest points of the nucleus is close to the color temperature. Important information was obtained on the surface layer characteristics of the nucleus. It is clear that there is no ice (or very little) exposed at the surface of the nucleus. The ice is covered by a thin layer of dark matter having a low thermal conductivity and to a considerable degree is porous, making it possible for water vapor to diffuse through it. Cometary ice is "dirty" and during its evaporation some percentage of the dirt remains at the surface (quite small particles can be carried away). Real proof of the presence of a dark mantle was obtained for the first time in the "Vega" observations. The thickness of this mantle may be from several microns to several centimeters. In order for the comet to retain its mantle it must have a large-pore structure not capable of holding back small particles. Figures 13; references 29: 5 Russian, 24 Western.

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Analysis of Hydrocarbon Band 3.35 in Spectrum of Halley's Comet Using Data From Infrared Spectrometer on 'Vega-1' Spacecraft
18660065q Moscow KOSMICHESKIYE
ISSLEDOVANIYA in Russian Vol 25, No 5, Sep-Oct 87
(manuscript received 8 Jun 87) pp 810-814

[Article by A. V. Grigoryev]

[Abstract] The spectral part of the "Infrared Spectrometer" instrument was described in another article in this issue of the journal (p 781), together with its operation during approach to Halley's comet and the method for reduction of the collected data. Five difference spectra were obtained giving the difference in intensities measured with distances to the nucleus 42, 50, 59, 68 and 90 thousand kilometers and from a distance of 193 thousand kilometers. Three emission bands of parent molecules were discovered: 4.3 μ (CO₂), 2.7 μ (H₂O) and a wide band at λ 3.35 μ , attributable to the characteristic vibrations of C-H bonds in hydrocarbons. The latter band is analyzed in detail on the assumption that the emitting matter is in a gaseous state and the excitation source is solar UV radiation. The analysis method is described and a qualitative interpretation and quantitative estimates are given. The band was first broken down

into three distinctive regions (3.22-3.25, 3.31-3.42 and 3.45-3.51 μ , corresponding to vibrations of different groups of atoms (listed in a table). Each of these three regions was analyzed in detail. The great width of the band precluded the possibility of its origin exclusively from methane, nor is methane the dominant component, nor can methane and ethane together explain the existence of region III. It was concluded that band structure can be explained only on the assumption of presence of alkanes more complex than ethane or naphthenes. The presence of molecules of one of the classes of unsaturated hydrocarbons, polyenes, must be postulated. The presence of aromatic compounds is possible, but the form of the spectrum differs from the spectrum of polycyclic aromatic hydrocarbons invoked for explaining the infrared emissions of interstellar dust. The flux of hydrocarbon molecules from the nucleus is estimated at 1.3×10^{29} s⁻¹. Figures 3; references 7: 2 Russian, 5 Western.

5303

Modifications to RT-70 Control Complex for 'Phobos' Project

18660030 Moscow. SOVETSKAYA ROSSIYA in Russian 6 Oct 87 p 4

[Article by L. Sergeyev]

[Abstract] The article recounts a visit to a radio control complex which is to be used in the upcoming project "Phobos". This project calls for studies of the planet Mars to be made with the aid of interplanetary stations.

The control complex includes a radio telescope, the RT-70, which was used previously in the "Vega" space project. This telescope is said to have the world's largest antenna that is completely rotatable. The complex, which formerly operated in the decimeter wave band, was being re-equipped for operation in the centimeter band. A new-generation transmitter called "Goliath", which has a capacity of 200 kilowatts, was to be installed here. This is necessary because plans for the "Phobos" project call for the spacecraft to be guided with a

precision of 5 meters at distances of millions of kilometers from the Earth, explained Oleg Petrovich Zverev, chief engineer of the complex. During the near stage of the flight from Earth to Mars, the spacecraft will be controlled with the aid of a transmitter called "Germes", which was also to be installed at the complex. This transmitter has a capacity of 10 kilowatts. The "Goliath" will be installed 55 kilometers above the ground and equipped with a water-cooling system.

A whole new set of data-processing and command equipment reportedly was being installed in the control complex. This equipment is said to include YES-1046 and YES-1061 computers. Re-equipping of the complex will permit complete automation of data gathering and processing, of transmission of this information to research centers, and of command writing and transmission of commands to the spacecraft, it is claimed.

A.S. Vyshlov, head of a laboratory of the USSR Academy of Sciences' Institute of Radio Engineering and Electronics and one of the scientists who were conducting trials of new equipment for the radio telescope, noted that in calculating the flight path of the "Phobos" spacecraft, effects of the Earth's atmosphere and the interplanetary medium must be taken into account, as well as the gravitational attraction of Mars and other planets. The planets' orbital parameters will therefore be determined with extra-high precision, using the RT-70.

Preparations for original experiments employing the RT-70 reportedly were being made by representatives of the USSR Academy of Sciences' Institute of Space Research. In the course of these experiments, which are called "Lima" and "Dion", the surface of Mars' satellite Phobos is to be irradiated with laser beams and bombarded with large ions of krypton, using special guns on board the spacecraft. Other instruments of the spacecraft will then analyze matter of the satellite's surface on the basis of reflected radiation and captured particles. Data from these analyses will be transmitted immediately to the RT-70.

FTD/SNAP /9738

Gazenko Interviewed on Problems of Human Adaptation to Space

18660059 Moscow IZVESTIYA in Russian 27 Dec 87
p 3

[Interview by B. Konovalov, science observer of Izvestiya, dateline Brighton/Moscow, under the heading: "An Interview with O. Gazenko, Director of the Institute of Medical and Biological Problems"]

[Text] Brighton, where the congress of the International Astronautical Federation was held this year, I stayed at the same hotel as O. G. Gazenko. Of course, I could not pass up the opportunity to question him about the inhabitation of outer space and its future prospects. Our conversation took on special importance in light of the completion of the longest space flight in history, with a new crew taking over the duty in orbit. **Question:** Oleg Grigoryevich, last year the entire world commemorated the thirtieth anniversary of the space age. What do you think the next thirty years will bring? What present trends will become important?

Answer: The past 30 years have proceeded under the banner of knowledge. This was the main consideration, after the launching of the first satellite in history, the flight of Yuriy Gagarin. Mankind entered a new world and explored it extensively over a very broad research front. We must frankly admit that the research slant was paramount in the spaceflights. And despite many practical accomplishments, cosmonautics has not yet produced any major revolutionary changes in the handling of earth affairs. True, weather forecasting has improved somewhat, television has arrived in remote regions through space, a rescue service is being organized, a search is under way for effective methods of studying various natural resources from orbit, and much else. But all of this, I should say, is mainly in the stage of demonstration of capabilities. In the next thirty years, a qualitative leap will occur. And the practical goals will come to the forefront in the development of cosmonautics. The primary technical means for this, in my view, will be the circumterrestrial orbiting stations, which have already proved their effectiveness to a sufficient degree. And here we might switch from the "battlefield reconnaissance" to well-planned industrial operations, utilizing the microgravitation, solar power, and other specific opportunities of space. **Question:** We have witnessed today the record flight, nearly a year long, of Yuriy Romanenko. How did space medicine ready itself for this flight?

Answer: The flight of Romanenko, in terms of its length, was of an investigative, one could almost say, an exploratory nature. And such flights into the unknown will continue. Of course, we prepared for this on earth. At our institute, ten subjects stayed in bed in conditions of relative immobility from April 1986 to April 1987. The purpose of this experiment was to work out various

means of prevention of the deleterious effects of weightlessness. Various physical loads, several kinds of conditioning devices, pharmacological correction substances, and new weighted suits were tested. The prevention regime was selected in view of the accrued experience and the individual characteristics of the subject. This work helped us in the flight of Romanenko, and will take on even greater importance in the future. We are presently continuing observation of the subjects. We can compare their condition with that of Romanenko.

Question: A year in orbit, of course, is an impressive figure. Could it be increased? Will there be longer timeframes for ordinary working flights, or should they be reduced?

Answer: In my opinion, the human being can work for one and a half to two years in orbit. It all depends on the layout, the degree of comfort, that will be achieved in the orbiting stations. Naturally, the role of sociopsychological problems will be heightened, perhaps to a greater extent than that of the physiological or biological. The situation is similar to that observed in polar environments. Some people cannot stand the conditions of the far north, for example, while others keep coming back for the winter, working for a long time in the polar stations. The profession of cosmonaut, again, is not yet an ordinary one. Therefore it is of practical importance to determine the optimal flight periods, taking into account the individual characteristics of each person.

Question: But do you foresee any major medico-biological barriers to life in space? Are all the changes you have observed in the body of the cosmonauts reversible?

Answer: There can be no talk of total reversibility. Simply because we cannot say, stop for a minute. In each successive minute, we become different individuals. This is unavoidable. In a half year or year a person in flight will become different, simply due to natural processes. But as for barriers, that is not an easy question. At present, space medicine is engaged in a seemingly strange task. We are doing everything so that the body of the cosmonaut does not forget earth. We are exerting every effort so that he does not become a spaceman, but remains an earthman. For the simple reason that he is to return from weightlessness to the gravity of earth. If a person were to remain constantly in space, this problem would automatically vanish. Apparently, man is endowed with sufficient plasticity to adapt fully to space conditions and feel at home there. Of course, he will become different, and much will change in his body. In space, from the standpoint of physical load, the conditions are easier for life than on earth. Less energy is needed, and the person has more freedom. He can float in weightlessness, like a fish in the water. These new abilities, over time, may become fixed. The person would be happy and content in space, but would find it incredibly difficult on earth. For this very reason, we require the cosmonauts to turn the pedals of the exercise bikes, to run on the treadmill, and to undergo vigorous

physical exercise. This is hard, at times they don't like it and feel like getting out of it. But in the end, the understanding that these sessions are the guarantee of an easier readaptation upon return to earth wins out.

Question: There is much talk today of an expedition of earthmen to Mars. But this would take around three years. Wouldn't an irreversible accustoming to weightlessness occur in that time? Wouldn't the landing on Mars and then the landing on earth be a disastrous ordeal for the crew?

Answer: To answer this question, we are presently gathering experience in lengthy flights orbiting the earth. If it turns out that a flight to Mars in conditions of weightlessness is undesirable, then artificial gravity should be used. Our experiments with animals in biological satellites have shown that they can cope with the biological problems pretty well. But a number of other ones occur. First and foremost, technical problems. It will be necessary to create a large donut-shaped structure, in which the person while revolving would be pulled toward the floor with the same centrifugal force as the gravity of our planet. But for scientific observations and work aboard the ship, there should also be a nonrevolving section, where weightlessness will prevail. The problem arises of the cosmonaut moving from one to the other. The transition in conditions might be abrupt. There is hardly any way to simulate this on earth. Short-term space flights, when the person moves quickly from the earth's gravity to weightlessness and back, might provide a kind of analogy. We know that problems of adaptation occur here. Serious problems might take place with a more sudden transition from artificial gravity to weightlessness and back, and this matter will need more investigation.

Question: Speaking of a flight lasting three years, it is clear that this would require tremendous reserves of water, oxygen, food. Obviously, all of this could hardly be carried along from earth. It would require systems with an artificial cycle of materials. How is science preparing for this? After all, this is also vital to the settlement of the moon and the other planets.

Answer: This problem was foreseen by K. E. Tsiolkovskiy. A number of scientific institutes of our country are engaged in it. Experimental work is also being done in space. But for the moment, we are being held back by a lack of strong energy sources. Even international organizations are becoming involved in this problem. In London, there is the International Institute of Ecotechnology. This is a commercial organization, which hopes to profit from the knowledge of the ways of solving ecological problems. This institute has purchased old silver mines in Arizona. They are presently building hermetically sealed rooms there, in each of which one of the biotopes of earth will be simulated, say, the savannah, the desert, the tropical forest, intensive agricultural production, and also the industrial activity of man. This system is known as Biosphere-2, in contrast with the

first, where you and I exist. Construction is to be completed in 1992, at which time it will be possible to examine the interaction between man and the environment rather accurately and quantitatively. At the same time, the problem of the optimal choice of an environment essential to human life beyond the earth will be solved. This is a question of providing a recycling of the atmosphere, the water, and some of the food for the crew by technical means. This will be a logical continuation of the work already being done in our country.

Question: At the opening of the congress in Brighton, the director of NASA, G. Fletcher, stated that in thirty years we might receive news of the birth of the first baby in a moon settlement. Is this prediction valid, in your opinion?

Answer: The scientific circles at present are discussing the question of the feasibility of creating moon settlements. From the standpoint of broadening the possibility of scientific research, the value of such settlements is beyond doubt. But it is not yet clear whether they might bring a practical benefit as well. And as I pointed out at the beginning, the financing of space projects in the coming decades will depend in no small way on their possible practical effect. It may be that large circumterrestrial orbiting stations will be more economically advantageous. As for the act of birth itself, no major obstacles can be foreseen at present. Experiments aboard biological satellites and orbiting stations on various subjects—flies, fish, certain animals—have shown that weightlessness does not preclude the formation of a new viable generation. And if families will work for a long time aboard the orbital stations, the moon or planetary settlements, then space children will also appear. There is no doubt that man is capable of inhabiting the solar system, continuing his species. But there is a danger that the ancestral home, our planet, will become alien to the offspring of space. They would hardly be able to live in the conditions of the earth's gravity. The future will show whether mankind will approve of being torn away from earth or not.

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Cosmonaut Laveykin's Condition Reported Practically Normal

18660032 Moscow TRUD in Russian 14 Nov 87 p 4

[Excerpt] A. Zhitkov of Orenburg writes: "At the end of July, it was reported that A. Laveykin, flight engineer of the spaceship 'Soyuz TM-2' and the orbiting complex 'Mir'—'Progress-27' was being 'recalled' from space because of illness. Since then, I have encountered no published materials regarding the state of his health. What happened to the cosmonaut in orbit, and how is he feeling now?"

Here is a reply from Candidate of Medical Sciences V. Bogomolov, one of the directors of medical support of space flights:

What happened was as follows. Disturbances of activity of the cardiovascular system were recorded in A. Laveykin during performance of an exercise tolerance test. These disturbances were expressed in a change of cardiac rhythm—what we call arrhythmia. Similar cases had been noted previously in the course of work of certain cosmonauts and astronauts, even on missions that were less prolonged.

The activity of the cosmonaut's cardiovascular system soon returned to normal during the mission. The arrhythmia recurred somewhat later, however. This phenomenon had not been encountered previously. If only a month or so had been left until the completion of the mission, no threat to the cosmonaut's health could have occurred. The end of the space mission was still very far off, however. And it appeared that the further continuation of so prolonged a space mission with all of its characteristic stresses could not be forecast with the necessary degree of reliability. Not wishing to risk the cosmonaut's health, medical personnel therefore decided that it would be better for A. Laveykin to return to Earth.

After returning, his period of recuperation proceeded smoothly. At the end of the summer, Aleksandr Ivanovich vacationed on the Black Sea coast, he swam and played tennis. A. Laveykin has undergone a complete series of examinations, including ones conducted at the All-Union Cardiology Research Center. Medical personnel have concluded that the changes noted during the mission were functional in character, a manifestation of individual features of his organism resulting from the effect of prolonged weightlessness. No pathology was discovered, and he is practically healthy.

FTD/SNAP /9738

'Cosmos-1887' Biological Satellite

Motion-Sickness, Tissue Regeneration Experiments on 'Cosmos-1887'

18660028 Moscow KOMSOMOLSKAYA PRAVDA in Russian 25 Sep 87 p 4

[Article by S. Leskov]

[Excerpt] The passengers of a new Soviet biological satellite are being prepared for the space launch. Only a few days remain until lift-off.

What kinds of scientific studies will be conducted on board this satellite? About 50 Soviet institutions and about the same number of foreign firms, representing socialist countries, the USA, France and the European Space Agency, have been taking part in their preparation. A single example indicates the scale of the work that is planned. "In the experiments with primates, principal attention will be focused on study of the mechanism by which motion sickness develops," related Doctor of Medical Sciences Ye. A. Ilyin, scientific director of the program. "Surgeons have implanted seven

electrodes in each monkey's brain, and scientists have penetrated to sections of the nervous system that were never observed previously. Recording of 30 physiological parameters will be done with the aid of these sensors and other instruments.

"Experiments with newts have also been very effective. Before the launch, one-third of a forelimb will be amputated and an eye lens removed from each of them. You needn't feel sorry for the newts, because their lost tissues will be regenerated. But at what speed? The answer to this question is important for the study of processes of wound healing in space, since injuries can happen to people, too."

Closed Environment Fish Breeding Experiment on 'Cosmos-1887'

18660028 Moscow PRAVDA in Russian 30 Sep 87 p 6

[Article by A. Tarasov, correspondent]

[Abstract] The article reports on final preparations, at the Institute of Medical-Biological Problems, for the launch of a satellite carrying biological specimens.

Doctor of Medical Sciences Inessa Benediktovna Kozlovskaya commented on results of earlier experiments with animals on board biological satellites. One important result of these studies, according to Kozlovskaya, has been the discovery that signals which the eye receives from the vestibular apparatus occur twice as frequently during the transition to zero gravity. This is believed to be a factor in the development of motion sickness. Scientists are now seeking ways of controlling this reaction.

Doctor of Biological Sciences Ganna Iosifovna Meleshko showed the author of the article a tank of the type in which chlorella would be grown on board the satellite. Plans for this experiment call for a closed ecological system to be created in such a tank. This system will include viviparous guppies, and bacteria of the pseudomonas type. Illuminated by an 8-watt bulb, the chlorella will grow, giving off oxygen and absorbing carbon dioxide. The chlorella will provide food for the guppies, and the bacteria will purify the water by digesting wastes. Results of this experiment may be used in development of fish-raising facilities for future space communities.

The flight program reportedly calls for 12 experiments to be performed in two weeks. It is recalled that two of these experiments were selected on a competitive basis from ones proposed by school children. These experiments are aimed at studying effects of zero gravity on regeneration of cells in planaria worms, and on bacteriophage activity of the colon bacillus.

Launch of 'Cosmos-1887' Biological Satellite
18660028 Moscow PRAVDA in Russian 30 Sep 87 p 1

[Excerpt] The "Cosmos-1887" artificial Earth satellite was launched from the Soviet Union on 29 September 1987.

Installed on board the satellite are sets of special scientific research apparatus which are intended for continuation of research of effects of space-flight factors on monkeys and other biological specimens, as well as apparatus for radiation physics studies.

In the course of the flight, experiments will be conducted to study process of adaptation to zero gravity, and to solve problems of ensuring the radiation safety of space flights. Two experiments will be conducted in line with a proposal of the Moscow City Palace of Young Pioneers and school children.

A substantial volume of the research and experiments is being conducted within the framework of a program of international cooperation for the study and use of outer space for peaceful purposes. Taking part in this research are scientists of the Hungarian People's Republic, the German Democratic Republic, the Polish People's Republic, the Socialist Republic of Romania, the Czechoslovak Socialist Republic, the United States, France and the European Space Agency.

The satellite was placed into an orbit with the parameters: initial period of revolution—90.5 minutes; apogee—406 kilometers; perigee—224 kilometers; orbital inclination—62.8 degrees.

The apparatus installed on the satellite is functioning normally.

Landing of 'Cosmos-1887' Reentry Capsule
18660028 Moscow IZVESTIYA in Russian
13 Oct 87 p 3

[Text] As has been reported to a TASS correspondent at the USSR Ministry of Health's Institute of Medical-Biological Problems, the reentry vehicle of the biological satellite "Cosmos-1887" landed in a non-specified area (Mirnyy, Yakutsk Autonomous Soviet Socialist Republic) on 12 October at 0703 hours Moscow time, following a 13-day flight. Biological experiments were conducted on board the satellite, including ones in line with programs of international cooperation. Work in line with the designated plan is in progress at the place of landing.

Biological Experiment Subjects Returned to Institute

18660028 Tashkent PRAVDA VOSTOKA in Russian
17 Oct 87 p 2

[Article by N. Zheleznev, TASS commentator]

[Excerpt] Specialists now have behind them all of the excitement caused by Yerosha, one of the passengers of the biological satellite, during his space flight, and all of

the subsequent anxiety connected with the unexpected landing of the satellite's reentry vehicle in the frigid taiga of Yakutiya. On 13 October medical personnel and engineers of the Institute of Medical-Biological Problems received a precious shipment from Kustanay, where a laboratory for preliminary postflight examinations had been set up.

With the exception of small guppy fish which like a warm environment, all of the program's experimental animals and biological specimens successfully endured both the flight and the adverse conditions at their landing place. The youngest authors of the international program, members of a biology circle of the Moscow Young Pioneers' Palace, and eminent scientists together have begun postflight studies.

Comment on Gravity Simulation Experiment on 'Cosmos-1887'

18660028 Moscow MOSKOVSKAYA PRAVDA in Russian 1 Nov 87 p 3

[Article by R. Ignatyev]

[Excerpt] A unique international space experiment ended recently. Monkeys named Drema and Yerosha, other animals and plants took part in it.

Is there a limit to the amount of time a human being can spend in orbit? Physicians and biologists are trying to answer this question. During the launching of the latest biological satellite, they tried to create artificial gravity in space. The experiment proceeded successfully. Rats placed in a special centrifuge found their weight again while rotating at a certain speed. Future spaceships and orbiting stations may be designed with special compartments, visits to which will be like visits to Earth for cosmonauts. The moment a crew returns to Earth, these compartments will convert automatically into isolation chambers in which people will gradually become accustomed to terrestrial conditions. A number of important problems involved in prolonged space missions will be solved when such compartments are organized.

FTD/SNAP /9738

Space Botany Research at Lithuanian Institute
18660031 Vilnius SOVETSKAYA LITVA in Russian
19 Sep 87 p 4

[Article by Rita Grumadayte, correspondent (interviewer)]

[Abstract] The article records comments of academician Alfonsas Merkis, director of the Lithuanian Academy of Sciences' Institute of Botany, regarding space research in which specialists of this institute have been taking part. Merkis is identified as a prominent specialist in space biology.

Cosmonauts on space stations have conducted a number of plant-growing experiments which were prepared at the botany institute and other Soviet research centers, Merkis relates. Among them are experiments aimed at solving problems of plant physiology and metabolism. Arabidopsis plants cultivated at the botany institute are descendants of plants grown in space four years ago. Scientists seek to determine how long reactions to terrestrial gravity persist in the genetic memory of these plants. Other botanical experiments are being conducted for this purpose on board the manned space complex

"Mir". Studies are also being made of plants' threshold of sensitivity to terrestrial gravity.

Merkis mentions that the institute is working on such practical problems as cultivation of food plants and creation of closed ecological systems on board manned spacecraft. In particular, scientists seek to develop and select varieties of plants which will be capable of yielding harvests comparatively quickly in space conditions.

FTD/SNAP /9738

Testing of Apparatus for 'Phobos' Mission

18660052 Moscow GUDOK in Russian 10 Dec 87 p 4

[Article by Ye. Nelepo]

[Excerpt] Less than a year remains until the beginning of the international expedition "Phobos." V.M. Balebanov, deputy director of the USSR Academy of Sciences' Institute of Space Research, told about the progress of work on this project.

"In the 'Phobos' project, questions of testing are particularly acute, since a completely new type of spacecraft is involved. A special testing unit, which is virtually an exact mockup of an interplanetary station, was developed at the institute to prove out sets of research equipment for this project. Each instrument is first checked individually with this unit. The whole set of equipment is then tested in three operating modes which simulate conditions of the upcoming expedition: Earth-to-Mars flight, drift over Mars' satellite Phobos, and movement in the Martian orbit."

"The mock-up of the interplanetary station will go on operating even after its space relatives are launched. It will help to analyze complex situations which may occur in the course of the research."

"Difficulties have occurred in the course of the testing. The two systems which have proved the most troublesome are the long-distance laser probing and television systems."

"The laser probing system was developed by specialists of seven countries: Austria, Bulgaria, the German Democratic Republic (GDR), Finland, the Federal Republic of Germany (FRG), Czechoslovakia and the Soviet Union. This system is intended for studying the composition of soil of [Phobos] with the aid of a laser beam—the first study of its kind in cosmonautics practice. The system's laser radiator has to release a relatively large amount of energy in a brief period of time—billionths of a second—and be reliable, small in size, and lightweight. The set of laser equipment includes a range finder which will be used to focus the laser beam on a spot only 1-2 millimeters in diameter, regardless of change in the distance between the spacecraft and the surface of the Martian satellite."

"Television pictures of Phobos will be taken in three spectral channels at once. This will make it possible to synthesize color images in which small details can be distinguished."

"Complaints in regard to the quality of apparatus were made to specialists of the FRG who are developing a data-processing unit for the laser probing system. A number of instruments had to be sent away for further improvement after serious errors were discovered in their designs. A magnetoplasma complex and a magnetometer were thus returned to Austria, and another

magnetometer was sent back twice to the GDR. The Swedish designers of a space-plasma analyzer came to Moscow several times. The shortcomings have been eliminated, but at the cost of extra expenditures of energy and money."

FTD/SNAP /06091

Soviet Space Transport Systems

18660061a Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 87 pp 18-26

[Article by S.D. Grishin, doctor of technical sciences and recipient of USSR State Prize, under the rubric "Space"; first three paragraphs are source annotation, fourth paragraph is source introduction]

[Text] The Great October Revolution produced the true blossoming of science and technology and it is natural that it is precisely our country which paved the way into space and inaugurated the space era in the history of Earth's civilization. Contemporary cosmonautics is making an appreciable contribution to increasing the efficiency of the national economy. It has become the leading sector in machine building and is on the cutting edge of scientific and technical progress. Space research also serves as an arena for international cooperation and is facilitating the growth of trust and mutual understanding between peoples.

Soviet cosmonautics holds a leading position in the world. Among its preeminent achievements in recent years the most impressive are the flight of the Vega automated stations to Halley's Comet and its up-close investigation, the beginning of the deployment in near-Earth orbit of the Mir multi-module scientific research complex, and the completion of ground testing and the beginning of flight tests of the new Energiya universal launch vehicle. Planting its own roots into "ground-based" sectors of industry, cosmonautics has become a unique integrator of advanced science and technology.

The development of cosmonautics and its technical level are determined in many respects by the means of space transport. They are intended to place space vehicles into near-Earth orbits and to send them to the solar system's planets.

Cosmonautics - An Important Element Of The Forces of Production And An Effective Means For Studying Nature

Only 30 years have passed since the first artificial satellite was placed into near-Earth orbit, but already it is difficult to imagine how radio, television, the weather service, navigation on the seas, geology, geodesy, hydrology, oceanography, agriculture, and forestry got by previously without space resources. Man has visited the moon and automated space vehicles have produced unique data about the planets which greatly exceeds in

volume and scientific importance what has been accumulated in observations by ground-based astronomical facilities. Mankind has firmly established itself also in near-Earth orbits and has learned to live and work in space for prolonged periods of time.

And all the same, these impressive and fundamental achievements of cosmonautics are only the initial stage of man's penetration into space. The 27th CPSU Congress assigned to the homeland's cosmonautics new tasks for the exploitation of outer space for peaceful purposes. This is the industrialization of space, the first stage of which is the organization of space-based production of high-quality semiconductor materials, superpure alloys and biomedical compounds and vaccines. Plans are being made to begin the establishment of a new technology sector—space-based machine building, and to set up the manufacture of space structures under weightlessness conditions, which will make it possible to decrease their mass and the consumption of materials.

The exploitation of space will also produce in the long run the opportunity for solving such an important problem as the overcoming of the limitations of power-supply and ecological considerations in the development of human civilization. Now, specialists working in the field of cosmonautics are discussing projects for the deployment in near-Earth orbits of solar power plants and production complexes. This will make it possible to reduce the consumption of ground-based fuel and power-production resources and to set up the space-based production of unique materials and superpure medicines. And what is very important—to send part of industrial production out beyond the limits of the Earth's atmosphere, where questions regarding the elimination of waste materials are simpler to solve without ecological limitations.

In the long run, the possibility is also being looked at of extracting raw materials for the space-based industry outside the Earth (using lunar rocks and meteorite materials) and establishing space settlements. A basic contribution will also be provided by space facilities in the solution of the fundamental problem of the origin and evolution of the solar system.

Therefore, cosmonautics is becoming an ever more substantial element of society's productive forces and a powerful means for penetrating nature's secrets.

The Soviet "Soyuz" and "Cosmos" Launch Vehicles

In the implementation of the broad-scale program for the exploitation of space, an important role is played by the **space transport systems**. By this is meant the set of vehicles which carry spacecraft from the Earth's surface to near-Earth orbits, ensure their landing on Earth, provide interorbital transportation of spacecraft, and also launch spacecraft into trajectories for flights to the solar system's planets.

The capabilities of cosmonautics are determined in many respects by the characteristics of the space transport systems. The first Soviet "Sputnik" launch vehicle and its variations, modified by mass placed into orbit, significantly exceeded the U.S. launch vehicles of that period. This is what made it possible in 1957 for our country to pave the way into space and later to carry out the first flights of automated craft to the closest planets and the first manned flights in the "Vostok" and "Voskhod" ships.

The updated "Soyuz" launch vehicle of the same class, which places a payload of nearly 7 metric tons into near-Earth orbit, is serving cosmonautics even up to the present time and it is used, for example, to launch the Soyuz-series manned ships and the Progress automated cargo ships, which deliver to the orbital stations crews, fuel, food, water and scientific equipment and instruments.

The "Soyuz" launch vehicle has three stages. The first and second are designed according to a **packet arrangement with lengthwise partitioning**.

The first stage consists of four strap-on units, 19 meters long and 3 meters in diameter, equipped with a four-chamber engine (with two steering chambers), which is capable of developing a total vacuum thrust of 102 tons. The strap-ons have a nearly conical shape and they are positioned symmetrically around a central unit and connected with it by two bands of power couplings—upper and lower.

The second stage is the central unit of the launch vehicle and is about 28 meters long with a maximum diameter of 2.95 meters. It is also equipped with a four-chamber engine (with four steering chambers), which develops a total vacuum thrust of 96 tons. And finally, the third stage is set on top of the central unit and joined to it with special rods. It is 8 meters long, 2.6 meters in diameter and has a four-chamber engine (with steering nozzles), which has a vacuum thrust of 30 tons.

The launch mass of the launch vehicle with the Soyuz-T ship amounts to around 300 metric tons, their total length is 49 meters and the maximum diameter is 10.3 meters. During the rocket's launching, the engines of the first and second stages are started simultaneously on the ground. But the second stage's engines continue to operate after the four strap-on units have been jettisoned; the third stage is started only after the second stage's engines cease to operate. An oxygen-kerosene fuel is used in all the launch vehicle's stages.

The transverse partitioning of the stages, the simultaneous starting of the engines of the first and second stages on the ground with monitoring of the intermediate processes, the technical checkout tests of the engines prior to their installation in the launch vehicle, and the

pre-launch systems check of the vehicle—all these things ensure the high degree of reliability of the "Soyuz" launch vehicle and the entire family of vehicles designed based on this vehicle.

In 1962, the **Cosmos** launch vehicle was developed in our country and was intended to launch small scientific satellites into near-Earth orbits. The mass of the payload which can be placed into a low near-Earth orbit by this rocket amounts to 1,200 kg. The "Cosmos" rocket is a two-stage rocket with tandem arrangement of the stages. The first is equipped with an engine with a thrust of around 63 tons operating on a bipropellant. The oxidizer is nitric acid plus additives and the fuel is a hydrocarbon. Installed in the second stage is an engine which develops a thrust of around 10 tons and operates on liquid oxygen and unsymmetrical dimethylhydrazine. The spacecraft itself is mounted on the second stage beneath a fairing which is jettisoned after the rocket passes through the dense layers of the atmosphere. The "Cosmos" launch vehicle is used extensively for placing Interkosmos-series satellites into orbit.

The Proton Launch Vehicle - A New Stage.

A great achievement of the homeland's cosmonautics was the powerful **Proton** launch vehicle developed in 1965, which in the three-stage variation places into orbit a payload of around 17 metric tons. This in turn made it possible to develop improved spacecraft for investigating the Moon, Mars and Venus, including the landing vehicles for studying the physical conditions on the surface of the Moon and Venus and the composition of the Venusian soil, as well as the automated vehicles for delivering lunar soil to Earth and for investigating Halley's Comet. The modified variation of the Proton launch vehicle can place into near-Earth orbits even larger loads— 20 to 21 metric tons and it is being successfully used now for launching orbital stations and space communications and television satellites into geostationary orbit.

The Proton launch vehicle has been constructed with transverse partitioning of the stages and, depending on its purpose, has from two to four stages. Installed in all the stages are economical, compact, single-chamber engines, which operate on a bipropellant: the oxidizer is nitrogen tetroxide and the fuel is unsymmetrical dimethylhydrazine.

The first stage is equipped with six engines with a total thrust of around 900 tons and the second stage has four engines, each of which develops a thrust of around 60 tons. The third stage has one of the same liquid-propellant engines and a steering engine with a thrust of around 3 tons, which has four rotatable chambers which provide the flight control for the last stage.

The total length of the Proton rocket (without the payload) is 44.3 meters and the maximum cross-section dimension is 7.4 meters.

Transport Systems Of The Near Future

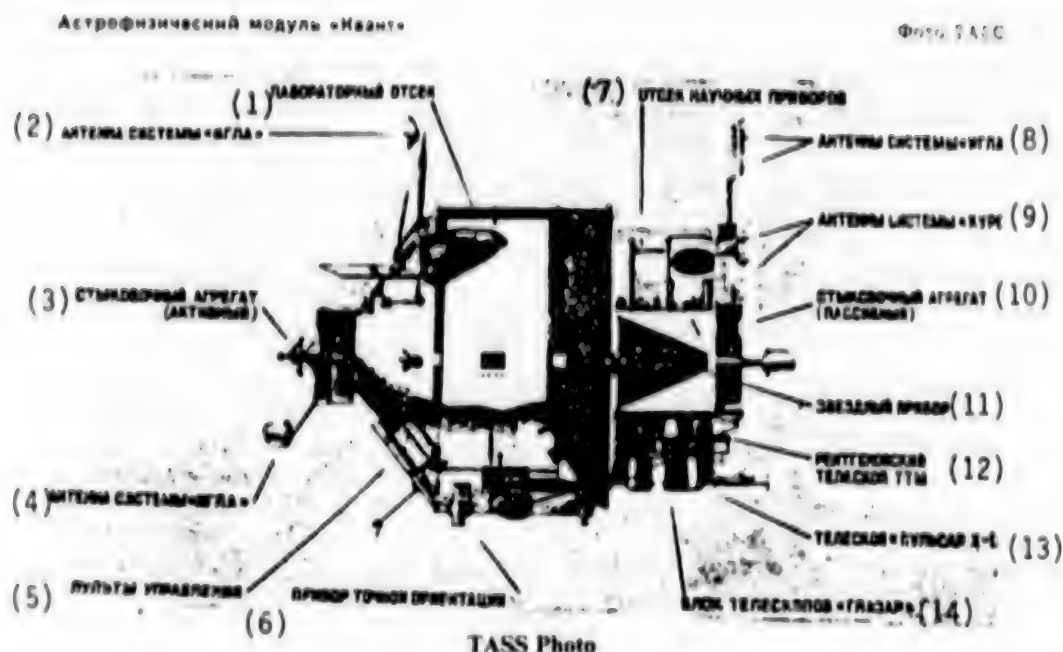
The USSR's "Cosmos", "Soyuz" and "Proton" launch vehicles and their modifications are **expendable launch vehicles** and all the structural elements, units and instruments of these launch vehicles can not be re-used. Annually in the Soviet Union, around a hundred spacecraft are launched and the necessary quantity of launch vehicles is manufactured for this purpose. The production and operation of the launch vehicles have been well tested, which ensures a high degree of reliability and a relatively low cost for the launching of spacecraft. However, cosmonautics' new tasks will inevitably require a substantial change in the appearance of space systems. The design basis of future space complexes will be large-scale structures which will require assembly in low near-Earth orbits from components and units manufactured on the ground or directly in space. In order to carry out the installation and assembly operations, specialized orbital assembly and operation centers will be established which will be equipped with the necessary equipment and its own staff of engineers and highly skilled workers. Also entering into the sphere of duties of the orbital centers will be repair and preventive maintenance work on spacecraft, the fueling of interorbital tugs and the launching of spacecraft into operational orbits.

The long-duration flights of the **Salyut-Soyuz-Progress** manned systems gave the homeland's cosmonautics unique experience in the operation of complicated multipurpose orbital complexes. This makes it possible to shift to the establishment of continuously functioning modular orbital complexes with replaceable crews. In our country the deployment of the first such complex has already begun: its base unit has been placed into orbit—the Mir orbital station and Kvant, the first astrophysics module (ZEMLYA I VSELENNAYA, 1986, No 6, p 2.— Editor's note.). In the future, other specialized modules with various types of equipment will be attached to the base unit.

On such a basis it is being proposed that, in the foreseeable future, space-based industrial complexes be built, including assembly and operations centers, power-production complexes and space platforms for communication, television, meteorological and natural science systems.

With cosmonautics' new tasks, the requirements for space transport systems are also being changed. What is becoming most important is the versatility of their use, i.e., the capability for rapid adaptation to various payloads, the high degree of productivity with regard to the launch rate and the cargo flow into outer space, the possibility of returning expensive instruments to Earth for repair and modifications and the low specific cost of transportation.

All this is impossible using just expendable launch vehicles. The opportunities for reduction in the cost of placing space devices into orbit using expendable launch



Key: 1.laboratory compartment 2."Igl'a" system antenna 3.docking unit (active) 4."Igl'a" system antenna 5.control panels 6.precision orientation instrument 7.scientific instrument compartment 8."Igl'a" system antenna 9."Kurs" system antenna 10.docking unit (passive) 11.star tracking instrument 12.TTM X-ray telescope 13."Pulsar-X-1" telescope 14.set of "Glaz" telescopes

vehicles are limited inasmuch as large production capacities are necessary for their manufacture. Moreover, with the use of the launch vehicles, exclusion zones are needed—water areas of the ocean free of shipping or unpopulated areas on dry land, where the separated stages fall. There is still one more problem—the "littering" of near space with expended upper stages of launch vehicles, booster units and spacecraft. (At the present time, there are several thousand such objects in space and their number is continuing to grow.) The fragments of space objects do not fall to the Earth's surface, rather, they burn up in the atmosphere's dense layers. But, they could become a danger in the future to newly launched spacecraft and to aviation, particularly to supersonic jets flying at high altitudes (up to 18 km) where the kinetic energy of such fragments has not yet dissipated.

What best satisfy the new requirements and are most advantageous from the economic point of view are the re-usable two-stage and, in particular, single-stage transport vehicles, which can be launched repeatedly (100 times and more) and which require only small repairs between flights. Such transport vehicles should be built along the design scheme of aircraft and should use atmospheric air as a supplemental fuel. Therefore, they need to be equipped with combination propulsion systems based on liquid-fuel and air-breathing jet engines. The mass of a payload that can be placed into orbit in one flight should amount to 30 to 100 tons. A space fleet of several such transport craft would be able to deploy

rapidly large-size space stations and platforms and power-production and industrial complexes.

However, before developing superheavy re-usable transport craft with a long operational life, it is necessary to solve certain fundamental scientific and technical problems. It is necessary to increase substantially the structural efficiency of the components of the space transport systems and, to do this, it is necessary to use new composite materials, heat-reflecting coverings and new designs for fuel compartments. It is necessary to develop ramjet engines with supersonic combustion which operate on hydrogen and also liquid rocket engines with a higher specific impulse.

The solution of all the problems will take a very long time. Therefore, in the near future, it is more rational to develop powerful two-stage launch vehicles with liquid rocket engines and first stages that can be returned to the ground and used repeatedly. These launch vehicles should be general-purpose, i.e., capable of placing into orbit both non-returnable payloads and returnable winged orbital ships, similar to the American Space Shuttle craft. If need be, they should ensure the return to Earth of expensive equipment for repair and subsequent re-use.

The "Energia" Launch Vehicle

On 15 May 1987, flight tests were begun in our country of the new and powerful "Energia" launch vehicle. It is a liquid, two-stage rocket with transverse arrangement of

the stages and lateral positioning of the payload. The structural basis of the launch vehicle is its second stage, which includes the tank system, the engine compartment and attachment fittings for the units of the first stage and the payload. The length of the second stage is around 60 meters and the diameter is around 8 meters. A high-power oxygen-hydrogen propellant is used in the second stage.

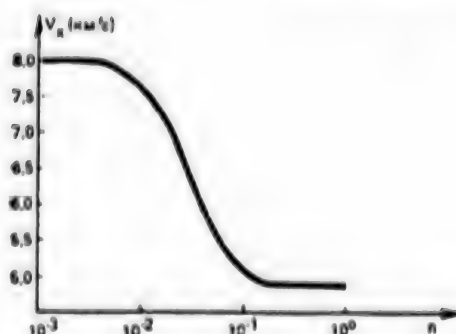
The rocket's first stage is made up of four strap-on units, which are liquid rockets operating on an oxygen-kerosene propellant. The launch mass of the rocket is around 2,000 metric tons and the mass of the payload placed into orbit is up to 100 metric tons. The first stage's engines develop a vacuum thrust of around 800 tons—these are the most powerful liquid rocket engines in the world at the present time. The thrust of the second stage's engines is around 200 tons.

All the engines of the first and second stages are started on the ground and their total thrust is around 4,000 tons. After the fuel in the first stage's strap-on units is expended, they separate from the second stage. The launch vehicle's second stage places the spacecraft into an orbit that is close to a closed near-Earth base orbit, after which the engines of a booster unit or the spacecraft are switched on and the required final orbit takes shape. After the separation of the payload, the second stage continues to move along a ballistic trajectory and its remains fall in remote regions of the Pacific Ocean.

The new "Energia" launch vehicle is a **universal** vehicle. While with the launch vehicle for the American reusable Space Shuttle ship the second stage's engines are located on the ship itself and, therefore, the second stage operates only together with the attached ship, which is the rocket's payload, on the "Energia" launch vehicle the second stage is not connected with the payload. Therefore, it is capable of placing into orbits payloads that are either **returnable to Earth** (for example, spaceships) or **non-returnable**.

Experience in the operation of Soviet orbital stations shows that the cargo traffic from the ground into orbit substantially exceeds the cargo traffic from orbit to the ground. It is necessary to send into outer space liquid rocket fuel, which is expended in the spacecraft in order to perform various maneuvers—maintaining the orbit, maneuvering during docking, orientation while conducting astrophysical and other research, as well as stores of food, water and various materials. All these things are used up completely during a space flight. The only things delivered to the ground are the results of the scientific research—samples of the obtained materials and medicines, photographic film and expensive components of scientific equipment, which need repairs and restoration under ground conditions.

Sending payloads into space in the cargo compartment of a reusable spaceship costs significantly more than sending it the usual way—without the ship. Thus, the American transport system using the Space Shuttle ship places



Зависимость характеристической скорости от перегрузки. Перелет с круговой орбиты (высота 200 км, наклонение 51,6°) на геостационарную орбиту (высота 36 000 км, наклонение 0°)

Relationship of characteristic velocity to load factor. Flight from a circular orbit (altitude 200 km, inclination 51.6 degrees) to a geostationary orbit (altitude 36,000 km, inclination 0 degrees)

into near-earth orbit a payload of around 30 metric tons, with the launch mass of the entire system amounting to around 2,000 metric tons. The mass of the ship itself amounts to around 80 metric tons. If a payload were to be sent up without a ship, then its mass would more than triple in size and would amount to around 90 to 100 metric tons. Correspondingly, the cost of placing it in orbit will be reduced.

Consequently, based on the "Energia" launch vehicle, it is possible to construct a universal and more economical system for orbiting payloads.

The Prospects For Interorbital Space Transport Facilities

The transportation of space structures and craft from low near-Earth orbits to high ones and to trajectories for flights to the planets is carried out at present by use of booster units. These are ordinary rocket stages equipped with liquid rocket engines. But, in contrast to rocket stages which are started on the ground, the space-based booster units are equipped with a system for starting the engines under weightlessness conditions.

With the development of space-based machine building the problem of transporting space structures to high orbits requires new engineering solutions and technical resources. Of principal importance is the selection of proper load factors during the transportation of large-scale structures from the reference orbit to the operational orbits. The load factors in the transportation process should not cause the collapse of the assembled structures.

It is customary to estimate the power consumption for space operations using the magnitude of the **characteristic velocity**—the total change in the absolute magnitude

of a spacecraft's velocity, necessary for performing a given space operation. The characteristic velocity changes in relation to the magnitude of the load factor (the relationship of the engine's thrust to the weight of the spacecraft under ground conditions). Thus, with load factors of from 1 to 0.2 (an acceleration of 10-2 meters per second squared), the necessary characteristic velocity for a flight from the circular reference orbit amounts to about 4.8 km/s. With a reduction in the load factor from 0.1 to 0.01, the characteristic velocity increases to 5-7 km/s, which is associated with the increase in the length of the flight and in the power consumption to compensate for the Earth's attraction. In the range of load factors from 0.005 to 0.0001, the characteristic velocity amounts to around 8 km/s.

Depending on the permissible load factor, there is a substantial change in the time for such a flight. With load factors of 0.1 to 0.01, it amounts to no more than a few days, with load factors of from 0.01 to 0.001—it increases by an order of magnitude (up to 10 days), and with load factors of around 0.0001, it increases yet one more order of magnitude (up to 100 days).

It is possible to use booster units with liquid rocket engines as transport facilities for delivering space objects from low orbits to high ones—with initial load factors no less than 0.1. The load factor increases continuously in accordance with the rate of expenditure of the liquid fuel and the decrease in the mass of the booster unit—if the propulsion system's thrust remains constant. In order to have the load factor remain constant over the course of the entire flight, it is appropriate to use propulsion systems with a large number of low-thrust engines. In the course of the flight, it is possible subsequently to turn off some of the engines and thereby reduce the thrust of the entire propulsion system.

It is appropriate to deliver cosmonaut crews to high orbits using space-based facilities with liquid rocket engines for the following reasons. First, in flying from low orbits to high ones it is necessary that a portion of the time be spent in the Earth's radiation belts where special protective measures must be used. Therefore, the faster the spaceship crosses the radiation belts, the less the danger to the cosmonauts.

A slow delivery of space objects to high orbits is feasible using booster units with electric rocket engines. This is accomplished by **plasma and ion rocket engines**, in which the supplied electric power is converted directly into the kinetic energy of the outflowing substance. In plasma engines, the working medium is plasma and its acceleration to high velocities (right up to 100 km/s) is accomplished in an electromagnetic field. In ion engines, similarly charged ions that are accelerated in an electric field, are used as the working medium.

The propulsion system in an electric engine system is made up of: an on-board power source (a solar or nuclear power plant), a system for storing and feeding the working medium and a plasma or ion accelerator.

In propulsion systems with liquid rocket engines, the power source and the working medium's source are one and the same — the liquid fuel. During combustion, it is converted into gaseous products, which, escaping through a nozzle, create the jet thrust. The power-production characteristics of a liquid engine, (for example, the specific impulse are limited by the efficiency of the fuel and the thermal properties of the combustion products. In systems with electric engines, the power source and the working medium's source are separate and the acceleration of the working medium is accomplished in electromagnetic or electric fields. This makes it possible to transfer energy to the working medium tens and hundreds of times greater than that of combustion processes and to obtain a higher value for the specific impulse.

However, electric rocket engines develop a low thrust and, for this reason, transport operations using them take a longer time. Thus, a flight from a low orbit to a geostationary orbit requires 60 to 100 days. But for a number of transport tasks, such prolonged flights are tolerable. For example, if large solar batteries are assembled in high orbits from components manufactured in a low orbit, it is expedient to transport such components using electric rocket engines which use the components of the solar batteries as the on-board power source.

Special emphasis should be placed on the fact that transport facilities with electric rocket engines are distinguished by a high ballistic efficiency, that they are capable of placing significantly greater loads into high orbits than facilities with liquid engines—and that this is with the one and the same initial mass. Their efficiency is especially high in two-way flights: **low orbit—high orbit—low orbit** (without refueling in the high orbit). In this instance, for example, during a flight from a low circular orbit with an altitude of 200 km and an inclination of 51.6 degrees (the standard orbit for a launch from the USSR's territory) to a geostationary orbit and back, a transport system with liquid engines is capable of returning to the low orbit with only 2-3 percent of the initial launch mass. For the same transport systems with electric rocket engines it is one order of magnitude greater: 20 to 30 percent.

In the remote future, it is possible to expect that laser rocket engines will be used in space transport systems. The power here will be transmitted to the launch vehicle or spacecraft from an external source, located on the ground or in space, using a laser emission. Very promising are **nuclear and thermonuclear engines**, where the energy from nuclear fission and fusion is used to heat a flowing working medium or for direct creation of thrust using microexplosions. The same can be said also about **solar sails**, in which solar radiation pressure is used for movement in outer space.

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COMMENTARY ON COMPUTERIZED LAUNCH CONTROL SYSTEM OF 'ENERGIYA' BOOSTER

18660102 Moscow IZVESTIYA in Russian 12 Jun 87
p 3

[Article by V. Karashtin, Doctor of Technical Sciences
and Professor; "How the 'Energiya' Rocket Works"]

[Text] On 15 May, the heavy, multi-purpose Energiya booster blasted off from the cosmodrome at Baykonur. Those who built the ground complex that provided the pre-launch preparations and the launch of this mammoth rocket made a significant contribution in the accomplishment of that task.

Every element of the complex was built with the features of the Energiya in mind—its power, the stringent requirements for operational reliability, the design features of the rocket itself.

An exhaust chute was built beneath the launch platform—for drawing off the powerful stream of gases from the engine nozzles during launch. It is a gigantic "scoop" that could hold an entire city block with buildings up to 20 stories tall.

When you consider the fact that 90 percent of the weight of the rocket that is blasting off consists of its fuel, it is not hard to imagine the large supplies of liquid hydrogen, liquid oxygen, and kerosene that must be kept on the ground in order to fuel the Energiya. Cryogenic components—oxygen and hydrogen—are stored in spherical tanks. Groups (by components) of these tanks are set up on the ground and are connected to the launch platform with pipelines. Both the spheres and the pipelines are covered with vacuum-shield [ekranno-vakuumnaya] thermal insulation.

In preparing the rocket for launch, technicians must have access to the detachable connectors that join the vehicle to the ground equipment such as fueling, drainage, or electrical gear and must be able to inspect the thermal insulation that covers the oxygen and hydrogen tanks of the second stage. A mobile service tower is used for this. On the launch complexes of the Soyuzes, the servicing frame tilts aside, but here, as with the complexes used for the Proton rockets, the tower rolls back a safe distance just before the launch. The tower has several service levels—"stories" and, with its hinged platforms, can envelop the rocket, providing access to practically any point on the rocket's surface.

The fueling and drainage mast of this launch complex differs from similar units used for other rockets in that one of its platforms is removed only after the rocket begins to move. The fact is that the hydrogen being fed into the rocket must in no way mix with atmospheric oxygen—that invariably leads to an explosion. Any excess of hydrogen is removed from the rocket by means of a special pipe.

The structure of the rocket itself also includes an innovation: cryogenic hardening of metal was used to lower the weight. The strength of the tanks, the onboard containers that are filled with compressed gas, and the assemblies inside the tanks was substantially increased at very low temperatures. This makes possible the use of thinner metal walls, although it imposes additional requirements on the technology for preparing the rocket for launch.

Extensive automation is the principal feature of the launch complex of the Energiya booster. The automatic control equipment has three components. The first, the automatic system for controlling launch preparations and start, is the "director" of the other components and is the only component that can issue commands to the rocket itself. The second component provides the first with the information it needs regarding the condition of the rocket. It measures such things as the temperatures of all the structural components of the booster and of the liquids and gases in containers; the pressures in the containers; instrument and compartment temperatures; engine pressures; fuel and liquid levels. All this information is processed and transmitted to the first control component so that it can generate the proper commands. The automatic equipment of the third component controls the feed of fuel components and gases from the storage tanks to the rocket and ensures safety of operations in the ground structures of the launch complex.

All of the equipment of the automatic control systems is based on domestic computers—serial production models as well as models developed especially for this complex. What made things difficult was that the equipment had to be designed simultaneously with the construction of the complex and with the development and manufacture of the rocket. When those who built the control system began their work, they did not yet have the final technology for preparing the rocket for launch or the entire list of elements that would have to be controlled.

Usually, it takes not less than three years to develop a computer network, to manufacture the instruments and their stands, and to conduct tests. When you take into account that the programs—without which the machines could not operate—must also be developed, you have to add at least two years to that. Because of the schedules assigned for developing the systems that would control the preparations and launch of the Energiya, it was decided to build equipment that would accept any program—in other words, tailor it so that it would solve any problem. Overall, this equipment is considerably more complex than the control systems used in nuclear power plants or in oxygen blast-furnaces. There, in fact, the facility's program of operation is known in advance, and the equipment is developed for a specific technology. Here, however, the process of preparing the rocket for launch had not been detailed in the beginning.

A special system for interconnecting a large number of computers was developed, and original solutions were presented for compiling programs. In computer centers,

programs are usually developed in the following sequence. An algorithm is written for a process and translated by a programmer into specific machine language. The program is fed into the computer and debugged, its discrepancies and errors removed. And only then is the machine operational.

The approach that was used for the Energiya complex excluded those steps. A method was used that represented the technology of the operation of the ground complex in the form of a special model—the so-called "law of control" ["zakon upravleniya"]. In scientific language, the developers rejected traditional programming and went over to a declarative representation of the technological process. The technicians present information in a form that could be immediately be used in the computer, eliminating all the functions of the programmer. For that, however, it was necessary to create additional programs that would provide machine comprehension of what the technician drew and wrote—numbers and letter abbreviations of control commands and objects.

The first-level system controlling the rocket consists of three identical computer complexes that are powered by two independent sources. Each machine has two processors that operate simultaneously. In all, there are six processors in operation. If one or several of them malfunction—even if only two remain in operation—the system's efficiency is not undermined. Only the volume of auxiliary service processes decreases. If one of the machines crashes or suspends the computing process, it will be restored by commands of the operative machines to the status of the computers that are operating normally.

The high degree of computerization has made it possible to make allowances for many emergency situations—a way out of them has been preprogrammed. In other words, more than 500 emergency situations have been transformed into standard programmed situations. In the most complex of events, the automatic equipment puts the rocket into a safe condition and it remains in the safe condition until the necessary decision is made. Human intervention, in terms of manual control, is provided for in the process of preparing the rocket.

The operator-technician of the first control component works at a console that has three color displays. The first display provides information on the issuance and receipt of its own commands and on the operation of the second and third control components. The second display provides information on the state of all the booster components. The third display is a back-up—it can display any kind of information. All of the consoles are identical in design and circuitry, and they are assigned tasks before each operation, depending on who is sitting behind the console: be it the director of the fueling operations, for example, the gas-supply engineer [tekhnolog gazosnabzheniya], etc.

During the entire time of pre-launch preparations, each of the operators issues no more than 3 to 5 commands provided for by the control law [zakon upravleniya]. In the event of an emergency situation requiring human intervention, the machine gives the operator advice—down to the specific button he must push.

Extra time is always written into the schedule of preparations for correcting possible malfunctions. Circumstances requiring the use of that time arose: in the process of cooling one of the tanks with gaseous hydrogen, an actuator "hung up" in the intermediate state and stopped responding to control commands. According to the program formulated by the technical instructions the true position of the actuator was determined, and then, with commands to the other actuators, the "hung" actuator was placed in the proper position. The processes for the remaining tanks and the other parallel operations were not interrupted.

And now the launch has been accomplished. The screen displays the communications: "The engine of the second stage of the booster has been shut down at the assigned time...The payload has separated."

A qualitatively new phase in the development of space has begun. Ahead lies a great deal of complex work.

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FEATURES OF 'ENERGIYA' BOOSTER, PROSPECTS FOR SHUTTLE

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[Interview with Academician V. Avduyevskiy; "The First Launch of the 'Energiya'"; subhead reads "The rocket has 170,000,000 horsepower"; the first two paragraphs in text appear in boldface in the source]

[Text] As reported already, our country has begun flight tests of the new, powerful "Energiya" booster. The booster is designed to lift into orbit modules for long-term stations, reusable spacecraft, and other large spacecraft that have scientific and economic aims.

The editors have asked Academician V. Avduyevskiy to comment on what is happening.

[AVDUYEVSKIY]: For more than twenty years now, Soyuz boosters, whose three-stage models are capable of lifting up to seven tons of payload into near-Earth orbit, have efficiently served the cause of developing and peacefully using outer space. They have been used successfully to launch many hundreds of vehicles with the most varied of purposes—manned spacecraft and transport spacecraft, for example, a considerable number of Cosmos satellites and Molniya communications satellites. For lifting the heavier cargos—as much as twenty tons or more—into orbit, we have the Proton booster series. Thanks to the Proton, near-Earth space has been

visited by the Salyut and Mir stations and the geosynchronous Raduga, Ekran, and Gorizont satellites; the unmanned Mars and Venera stations have set out on interplanetary voyages; and the international Vega project was successfully realized. The USSR also has other rockets. All of them are noted for their reliability, which stems from standardized, well-proven components.

But the pace of development of cosmonautics is swift—what yesterday bordered on fantasy, today is ground that has already been covered in the development of near-Earth space. Scientists dream about creating large scientific-research laboratories in orbit, about space factories that will use weightlessness and the profound extraterrestrial vacuum to produce ultrapure substances, unique alloys, vaccines, and other medicinal preparations. Plans for manned lunar stations and expeditions to Mars are developing.

A more powerful booster is needed to accomplish such tasks. And now, it has been developed by Soviet scientists, engineers, and workers.

The rocket consists of a core unit, with four strap-on units. The core unit has four engines, and the strap-ons have one each. The engines of the strap-on units are the most powerful in the world. The overall power of the rocket is 170 million horsepower. Liquid hydrogen and liquid oxygen are the fuel components in the core unit.

The launch weight of the Energiya is more than 2,000 tons; its height is about sixty meters. The Energiya, as you know, is capable of lifting a payload of more than 100 tons into space. That is twice the weight of the scientific complex, now in orbit, that includes the Mir station, the Kvant module, the Soyuz TM-2 manned spacecraft, and the Progress-30 freight vehicle.

But the new rocket is remarkable not only for its immense power. It is noteworthy for the reliability and efficiency of its engines and for its innovative design solutions.

The operation of all the rocket's assemblies is monitored and controlled by smart computers that execute the given flight program. A special feature is the complete automation of the pre-launch servicing, fueling, and monitoring of onboard systems at the launch and during flight.

The software of the new booster is better than that of any of the previous rockets by a factor of two. Computers control and monitor more than two thousand parameters. This is possible thanks to the fact that the launch site is equipped with a powerful computer center that controls most of the assemblies and mechanisms that take part in the flight preparations. It interacts with onboard computers that continuously monitor all of the rocket's systems on the launch pad.

Overall, it can be said that the development of this new rocket represents a grand leap in technology and testifies to the great advances the USSR has made in the area of space machine-building.

[IZVESTIYA]: You speak of reliability, but as we know, the goal that was set was not fully accomplished.

[AVDUYEVSKIY]: We're speaking of booster reliability, and there is no contradiction here. On 15 May at 2130 hours, the Energiya departed for the heavens, and many of you saw that impressive launch on television. The rocket flew with no problems throughout the entire active section of the flight. The first stage worked for its appointed time, and then the second stage took up the baton just as precisely and carried a mock-up simulating a payload to a calculated point in near-Earth space. Then, as called for by the program, the mock-up separated from the rocket. Thus, the Energiya carried out completely the task it was assigned. Both stages of the rocket were checked out under actual flight conditions. The developers received a colossal amount of information on the behavior of the rocket's structure and all its onboard systems in flight. The preliminary results of the analysis of these data are already inspiring confidence that this new space giant has a grand future.

The mock-up that simulated the size and weight of a payload and that separated from the rocket had to use its own engine to enter a circular orbit. There was, however, a malfunction in the operation of its onboard systems and it did not enter into its assigned orbit. The mock-up's attitude control system incorrectly fired during the operation of its engine, which was supposed to transfer the mock-up to a higher orbit. The failure is, of course, distressing, but it has nothing to do with the Energiya rocket.

[IZVESTIYA]: So, can we expect the launch of a reusable Soviet spacecraft soon?

[AVDUYEVSKIY]: If you carefully reread the report on the launch of Energiya, you will see that it contains no specific promises on that account. It speaks only of the fact that the use of the new universal rocket will enable us to launch such spacecraft as well as large scientific modules. If we give rein to our imagination, we could also add to the list things like orbiting solar-power stations or interplanetary spacecraft. But that does not at all mean that all such technology will be launched in the near future. Just what systems will be given priority depends on what direction the development of outer space takes. It is important is that the Energiya can become a good base for realizing large international projects in the area of space research.

The successful launch of the new rocket convincingly demonstrated to the world the great possibilities of our space technology.

FEATURES OF "SOYUZ TM" SPACECRAFT *18660122 Moscow PRAVDA in Russian 5 Aug 87 p 3*

[Article by Yu. Semenov, doctor of technical sciences, and V. Timchenko, doctor of technical sciences: The Family of "Soyuzes", under the rubric "The Mir Orbital Complex: Our Commentary"]

[Text] /With the landing of cosmonauts A. Viktorenko, A. Laveykin, and M. Faris in the Soyuz TM-2 descent module, the first manned flight of a transport ship of this type came to a successful end. Soyuz TM was created on the basis of modern designs and technical progress as a modification of the Soyuz T and is equipped with many newly developed systems and assemblies, expanding its application possibilities. The position of the Soyuz TM spacecraft in the development of Soviet space programs is dictated by the need for support of long-term orbital complexes, which are themselves undergoing modernization. Under such conditions, new and heightened demands are placed on the vehicles.

The experience with operation of the Salyut stations and analysis of the required cargo flow between Earth and the station have revealed that the return of cargoes is becoming a frequent trouble spot. Such cargo includes the results of scientific investigations, as well as instrument assemblies which have been replaced aboard the station and are in need of analysis on Earth to further improve the reliability and service life.

Experience has also revealed that individual critically needed payloads of quite large dimension are best transported to the station by a manned ship. At the same time, in certain situations the ship should be fully loaded with fuel, in order to assure its flight in orbit at high inclinations which, as we know, requires additional weight expenditures. All these goals came down to the single conclusion as to the advisability of further modification of the Soyuz T, in particular, lowering its weight and boosting its payload capacity.

At the same time, the need to replace certain, although well proved, nevertheless "aging" elements of the Soyuz T systems had become evident. Thus, even during the test flights of the Soyuz T vehicles, the direction and goals of its further improvement were understood.

Externally, Soyuz TM is little different from Soyuz T: it uses the same well proved configuration, the same principles of connection to the booster rocket and design of the emergency rescue system. However, the new ship is very favorably different from its precursor in terms of specifications, design and systems.

The descent module of the ship is furnished with a new main and reserve parachute system, equal to the best international standards. The parachute canopies are made of lightweight fabric, while the reinforcing skeleton and lines are made of braided materials based on a new synthetic fiber, which sharply cuts down on weight. The

parachute design was altered to accommodate the properties and characteristics of these materials. This greatly reduces the volumes of the parachute containers, accordingly freeing up space in the descent module.

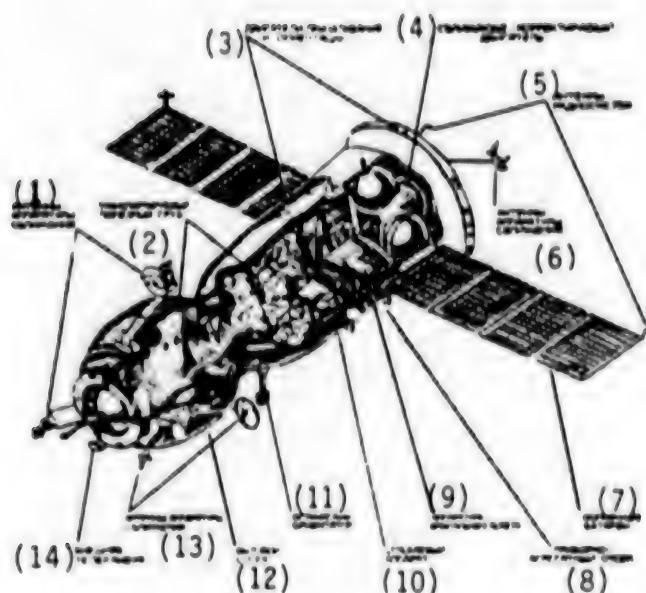
The descent module has also been reconfigured in part. Modernized electric power supply units and an improved altimeter for activating the soft-touchdown engines have been installed. Furthermore, the design of the chairs has been standardized, and areas have been set aside for stowing the cosmonaut's gear. The descent module has become more comfortable and reliable in operation, and is now able to return additional payload from orbit to the ground.

Soyuz TM is launched by an improved booster rocket, capable of putting into orbit a payload somewhat larger than that of Soyuz T. In addition, around 140 kilograms of payload have been gained by the modernization of the parachute systems. Thus, it was possible to increase the payload placed in orbit by 250 kilograms.

The combined propulsion system of Soyuz TM, while preserving the general structure, has been given a new base block, consisting of the fuel tanks, a fuel feed system, and a sustainer engine. The principal differences consist in use of metallic dividers of the tanks, helium as the working agent of the displacement system, sectionalization of the fuel reserves and duplication of their feed lines, and a sustainer engine of original design with noncooled nozzle. These modifications are directed at improving the operating performance of the ship's propulsion system and bettering its reliability.

Soyuz TM is equipped with an improved platform-less inertial guidance system, based on the onboard computer complex and capable of executing all basic guidance regimes automatically or with participation of the crew. New high-precision angular velocity meters and new precision linear acceleration sensors have been developed specially for Soyuz TM, improving the accuracy of guidance and navigational operations. There has been an upgrade in the level of diagnostics of the onboard systems performed by the computer complex during the guidance process for maximum utilization of the reserve capabilities of the ship and its systems.

Of major importance to the operation of the orbital complexes is the introduction of a new method of approach and docking. Now, the station or complex does not change its attitude in the given system of coordinates. Instead, the ship approaching from one of many different directions flies around the station, moves up to the "docking cone", approaches and docks at the particular module. During flights of the unmanned Soyuz TM and the manned Soyuz TM-2, this complex and promising scheme of approach was executed in automatic mode for the first time. During its implementation, the guidance system handles the problems of attitude control,



**ОСНОВНЫЕ ХАРАКТЕРИСТИКИ
КОРАБЛЯ «СОЮЗ ТМ»**

Экипаж	3 чел.
Масса корабля	7070 кг
Масса спускаемого аппарата	3000 кг
Длина корабля по ширине	6,98 м
Максимальный диаметр	2,72 м
Размах солнечных батарей	10,6 м

Basic Specifications of Soyuz TM Ship:

Crew: 3 persons
Mass of Ship: 7070 kg
Mass of Descent Module: 3000 kg
Length of Ship: 6.98 m
Maximum Diameter: 2.72 m
Span of Solar Batteries: 10.6 m

Key:

- | | |
|-----------------------------------|------------------------------|
| 1 rendezvous antenna | 8 instrument module |
| 2 transported payload | 9 orbital flight apparatus |
| 3 docking and orientation engines | 10 descent module |
| 4 rendezvous correction engine | 11 optical orientation point |
| 5 radio antennas | 12 orbital module |
| 6 rendezvous antennas | 13 rendezvous antenna |
| 7 solar batteries | 14 external TV camera |

autonomous navigation and guidance, relying on measurements of the mutual position of the ship and the station sent by the "Kurs" system, a new and promising radiotechnical measuring complex.

In the development of the ship, much attention was paid to flight safety and reliability. The design preserves the

backup duplication of mechanisms, while the primary electrical systems are in triplicate. Backup lines have been provided in the pneumohydraulic systems. An extra backup regeneration cartridge has been added to the life support system, sufficient to execute descent in event of disturbance in the oxygen supply. For better

reliability of Soyuz TM and crew safety, many other measures have been adopted. An important feature of the ship is the possibility of changing its flight program, when necessary.

The flight of Soyuz TM-2 was a new step in the creation and refinement of ships intended for operation of long-term orbital complexes. With the addition of this type of ship to the fleet, there are greater opportunities for the servicing and development of orbital complexes and for carrying out scientific research and experimentation.

12717/9738

Development of Technology for Space Production Processes

18660026 Moscow ZEMLYA I VSELENNAYA in Russian No 5, 1Sep-Oct87 pp 6-11

[Article by V. S. Avduyevskiy, academician, and L. V. Leskov, doctor of physical and mathematical sciences: "Frontiers of Soviet Space Technology"]

[Text] Cosmonautics has entered a new stage, the industrial exploitation of space. This article tells about the most important stages in this promising direction in Soviet cosmonautics.

Three decades have passed since the time of launching of the first artificial earth satellite in the USSR. These years were characterized by the vigorous development of cosmonautics. These years were filled with new advances, many of which were of a fundamentally important character.

As a result of these successes the industrialization of space (the most important trend in practical terms) and, in particular, the field of space technology were formed and became fundamental in the development of modern cosmonautics. The solution of three interrelated problems is now at the center of attention of space technology: — research on processes of heat and mass transfer, phase transitions and surface phenomena for the purpose of development of the corresponding fundamental scientific discipline and, on this basis, further development of existing production operations under weightlessness conditions. — space production of new and improved organic and inorganic materials; — mechanical engineering in space, including the building of large orbital structures, assurance of their reliability, durability of materials and construction components.

Work on these aspects of space technology has been carried out in the USSR, the United States, Western Europe, Japan and other countries. We will examine the most important landmarks in the work carried out in the Soviet Union.

Scientific Principles of Space Technology

A new scientific field of a complex character, the mechanics of weightlessness, has developed at the juncture of the theory of heat and mass exchange, hydrodynamics and the theory of phase transitions and surface phenomena. This discipline is concerned with the physical conditions existing on board space vehicles. Due to the specific nature of physical phenomena under weightlessness conditions it is specifically hydromechanical effects and heat and mass exchange which exert the main influence on technological operations. The first cycle of Soviet complex experiments on the physics and mechanics of weightlessness was prepared after the welding experiments on the Soviet spaceship "Soyuz-6" (1969) and the "Universal Furnace" experiment carried out within the framework of the joint Soviet-American "Soyuz"- "Apollo" program (1975). The mentioned experiments were carried out in 1976-1977 aboard the Soviet "Salyut-5" orbital station. A study was made of such processes as mass transfer, crystallization of melts from a free surface, growth of crystals from a solution and flow of fluid in capillaries under weightlessness conditions (ZEMLYA I VSELENNAYA, No 6, p 24, 1978 — editor). The cycle of experiments carried out aboard the "Salyut-5" station revealed that weightlessness exerts a complex and indeterminate influence and revealed the need for special theoretical and experimental research on space technology problems.

The first Soviet multipurpose program of large-scale technological experiments was carried out in 1976-1982 under brief weightlessness conditions aboard high-altitude rockets of the "Mir-2" series. During this time there were seven launchings of high-altitude rockets on which about 130 technological experiments were carried out for directed and volumetric crystallization of samples of semiconductor materials, alloys and vitreous media. The series of rocket experiments confirmed the possibility of improving the quality of different materials and made it possible to study the peculiarities of crystallization without a container and methods for capillary molding, growing of perfect bars of germanium and silicon by a new fast crystallization method. Many of these results are of priority importance.

One of the initial tasks in scientific support of space technology was a determination of the constant and variable microaccelerations operative aboard space vehicles and capable of exerting an influence on technological processes. The first direct measurements of such microaccelerations were carried out in the USSR in 1978-1980. A special instrument, an accelerometer, was developed for this purpose. This was used in carrying out technological experiments on high-altitude rockets, on the unmanned "Progress" transport ship and on the "Soyuz-6" orbital station. As a result there was found to be a dependence of the level of small accelerations on the spacecraft operating regime.



Figure 1. "Pion-M" apparatus designed for complex research on physics of fluids and crystallization under weightlessness conditions.

Mathematical modeling methods can be an effective tool in research on the general laws of the physics of weightlessness. These methods are based on the equations of mechanics of continuous media in combination with modern methods for numerical solution on high-speed computers. Work directed to construction of numerical models for describing heat and mass exchange and crystallization processes when carrying out technological procedures under weightlessness conditions was initiated in the USSR in 1976. A set of computer experiment programs has now been developed which makes it possible to investigate the peculiarities of many technological processes under weightlessness conditions and to predict their results.

Unfortunately, the broad use of numerical modeling methods in the synthesis of materials applicable to real conditions on a spacecraft meets with a number of difficulties (variability of microaccelerations, uncertainty in conditions on interface boundaries, lack of information on thermophysical properties of many substances of practical interest, etc.). For this reason it was desirable to consider the possibility of physical modeling of heat and mass exchange processes. As a result of research on this problem in 1980 a method was proposed for partial modeling of such processes, which is ensured when there is an equality of one or more dimensionless criteria which play an important role for the process under study. Within the framework of such an approach an apparatus was constructed in the Soviet Union in 1980 for carrying out complex research on the physics of fluids and crystallization under weightlessness conditions, the "Pion" apparatus.

The "Pion" apparatus is based on the shadow method for registry of optical inhomogeneities in a fluid. The first experiments for research on convective processes under weightlessness conditions using this instrument were carried out on the "Salyut-6" station in 1981. Similar experiments abroad began only two years later aboard the orbital module of "Skylab-1" using a fluid physics module developed by the Fiat Company.

After the first successful experiments on the "Salyut-6" station the "Pion" apparatus was considerably improved

and its modified variant, the "Pion-M," was systematically employed within the framework of experimental materials science programs which were carried out in 1982-1987 aboard the "Salyut-7" and "Mir" orbital stations.

Space Technology and Production

The next problem in space materials science which had to be solved was a determination of the classes of substances and the technological processes for their preparation under space conditions most promising in the first stage of space production. For this purpose the electrically heated "Splav-01" and "Kristall" furnaces were constructed in the USSR (ZEMLYA I VSELENNAYA, No 3, p 25, 1979. — editor), as well as the "Kristall-Magma," designed for carrying out technological experiments with inorganic materials, and the "Tavriya" as well as some other units for experiments with biomedical preparations.

During 1977-1982 the "Splav-01" and "Kristall" apparatus aboard the "Salyut-6" orbital station was used in carrying out about 200 technological experiments with samples of semiconductor materials, alloys and vitreous media. Experiments with materials of these classes were continued in 1982-1986 with materials of these classes using the "Kristall" and "Kristall-Magma" apparatus.

An analysis of the results of experiments with inorganic materials indicated that semiconductors are the most promising in the first stage of space production development. These experiments revealed: the production of some semiconductor materials (for example, germanium and silicon, indium antimonide and cadmium sulfide) under weightlessness conditions has a number of important advantages in comparison with ordinary ground-based technology. On the basis of a generalization of the results of experiments on high-altitude rockets it was possible to discriminate the most promising methods for growing these materials under weightlessness conditions (zone refining without a crucible, gas transport methods, fast directed crystallization, etc.).

In addition to successful experiments in the field of space semiconductor materials science, interesting space metallurgy experiments were also carried out in 1976-1982 on the "Salyut-6" station. In particular, a study was made of the possibility of preparing improved samples of magnetic and superconducting alloys under weightlessness conditions. It was found that the transpiring of metallurgical processes under weightlessness conditions results in considerable changes in phase composition, size and configuration of phase inclusions and size of crystal grains. Some of these changes result in an improvement in many properties of this group of materials.

Experiments on another aspect of space research on inorganic materials, the production of vitreous media, were carried out using high-altitude rockets and the

"Salyut-6" station. It was demonstrated that space samples of phosphate and other glasses have properties different from their laboratory prototypes. In some cases the structure of space samples was improved, defect density was reduced and transparency increased.

Biotechnology experiments were carried out repeatedly on the "Salyut-7" station, beginning in 1982. The objective of these experiments was to obtain a number of biomedical preparations of ultrahigh purity. Most of the experiments were carried out using the "Tavriya" apparatus (ZEMLYA I VSELENNAYA, No 3, p 5, 1984, — editor). A purified anti-influenza vaccine and interferon samples were obtained in 1984 using this apparatus. Experiments with preparations of livestock feed antibiotics needed for the accelerated development of livestock production were also carried out.

The results of biotechnology experiments carried out in 1982-1986 in the Soviet Union gave evidence of the good prospects for this aspect of space production. The possibility appeared for proceeding to the next work stage: space production of biomedical preparations of particularly high purity for use in the public health sector.

For the purpose of increasing the efficiency of research in the space materials science field some of the experiments were carried out in 1978-1983 within the framework of the "Interkosmos" program with the participation of specialists from member countries of the Council for Mutual Economic Aid, as well as France and India. The experiments were carried out on the "Salyut-6" and "Salyut-7" stations using the "Splav-01," "Kristall" and "Kristall-Magma" apparatus.

Some of the experiments carried out within the framework of the international cooperation program are important for formulating the scientific principles of space materials science. In some experiments results were obtained which make a useful contribution to thermal physics and other fundamental scientific disciplines. For example, more precise values of the coefficient of diffusion of copper in molten aluminum were computed using the results of the Soviet-Hungarian "Bealutsa" experiment ("Salyut-6," 1980).

Direct experiments in space demonstrated that the production of improved materials on space vehicles is in principle possible. But in orbital experiments a number of unexpected effects also appeared: detachment of melt from the walls of the technological ampule, a high role of thermocapillary convection, relatively rapid growth of perfect monocrystals and others. The need appeared for continuing theoretical and experimental research for the purpose of formulating the scientific principles of space technology.

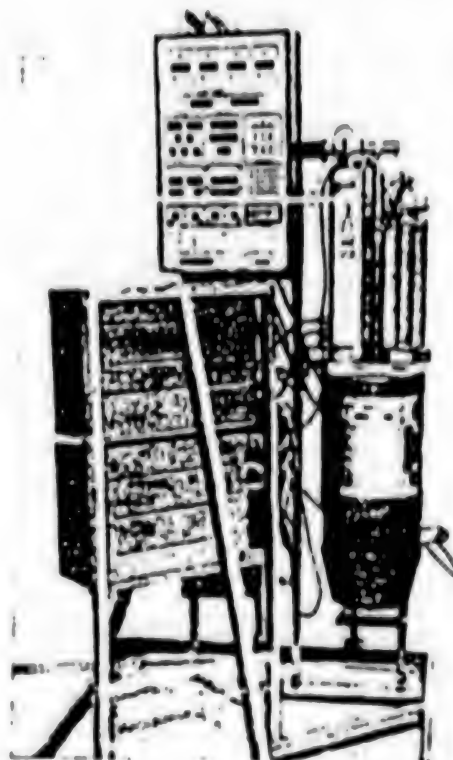


Figure 2. The "Tavriya" apparatus makes it possible to investigate the process of space production of biomedical preparations with ultrahigh purity.

A series of such experiments was carried out with the "Pion" and "Pion-M" apparatus on the "Salyut-6" (1981), "Salyut-7" (1982-1985) and "Mir" (1987) stations. In these experiments, for the first time in orbital flight, research was carried out on the development of thermocapillary convection in a fluid from a free surface and different methods for its suppression were tested. A study was also made of the dynamics of molding of melts under the influence of the forces of capillary pressure and the crystallization of samples. Methods for the control of thermocapillary drift of gas bubbles in a fluid, either for their elimination or fixation, were also investigated. In addition, the first test experiments in the field of colloidal chemistry for the study of hydrosols and aerosols ("Kolosok" experiment) were carried out for the first time in 1987 on the "Mir" station.

A generalization of the results of experiments in the field of space materials science has made it possible to proceed during recent years to construction of theoretical-computation models of specific technological processes in the production of materials, taking into account the real conditions prevailing on a spacecraft.

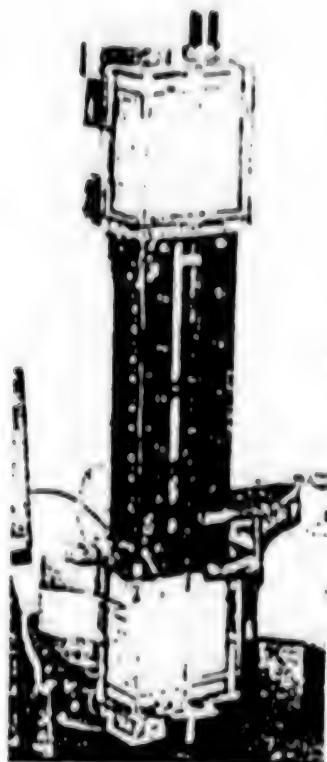


Figure 3. The "Korund" apparatus is used for the experimental-industrial production of semiconductor materials in space.

The successes in research on space materials science problems attained by the beginning of the 1980's served as a basis for defining the next task in space technology: designing and construction of a new generation of technological apparatus. By 1982-1984 prototypes of specialized apparatus had been constructed in the Soviet Union for experimental industrial production of semiconductor materials in space ("Korund," "Korund-1M" and others). The "pilot" apparatus in this series, the "Korund," in 1982 successfully underwent debugging tests on the "Salyut-7" station, during which the monocrystals used in a number of electronic instruments were grown. In 1987 an improved model of this apparatus, the "Korund-1M," was delivered to the "Mir" station. Its weight is 132 kg, power consumption — up to 1000 W, diameter of samples — up to 25 mm, temperature — up to 1200 degrees C. The "Korund-1M" apparatus was used in carrying out a program of experiments for perfecting six basic technological processes for 10 different semiconductor materials. The operation of this apparatus is highly automated.

A complex approach was employed for the first time on the "Mir" station for highly productive work in the field

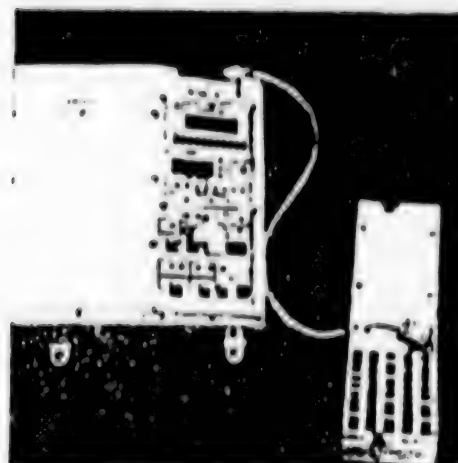


Figure 4. The "Isparitel" apparatus makes it possible to perform repair and restoration operations in open space.

of space materials science and technology. The approach involves simultaneous performance of experiments for production of materials using the "Korund-1M" apparatus and physical research on processes transpiring under weightlessness conditions using the "Pion-M" apparatus.

Space Mechanical Engineering

In the long run the expansion of industrial production of organic and inorganic materials in space will require the construction of specialized automatic orbital energy-producing complexes. Such complexes will include the technological modules of permanent orbital stations and unmanned technological platforms in autonomous flight. An important advantage of automatic platforms is that aboard them it will be possible to ensure a minimum level of microaccelerations which exert a harmful effect on technological processes (not more than 10^{-5} to $10^{-6}g$).

A solution of these problems is possible only on the basis of a new approach to the principles of designing of space equipment. Traditional mechanical engineering is based on the laws of universal gravitation. The changeover to the operation of structures under weightlessness conditions, a vacuum, intense radiation fluxes and sharp temperature drops requires the "cosmosization" of mechanical engineering. The exceptionally radical changes in construction, architecture and methods for erection, assembly and repair of objects in space make it necessary to take weightlessness into account. A whole series of complex requirements must be taken into account for prospective space objects: the need for high reliability, standardization, adaptability and possibility of subsequent reconstruction directly in orbit. Space mechanical engineering is being born before our very eyes. This is the technical foundation on which work is

developing on the industrial exploitation of space. What has already been done? A new step in the construction of orbital production complexes was taken in the Soviet Union in 1985 with the launching of the "Cosmos-1645" satellite, which carried an automatic technological laboratory. Tests were performed for 14 days with the "Splav-02" and "Zona" apparatus, designed to obtain semiconductor materials by different methods, during the flight of this space vehicle. This research yielded a number of interesting results. In particular, space samples, in comparison with terrestrial analogues, have a more perfect structure and they do not have a layered nonuniformity of impurity distribution. Without question the construction of such an automatic technological satellite is an important stage in implementing the program for industrial exploitation of space.

At the present time work is being energetically carried out on Soviet orbital stations for testing methods for erecting and assembling large structures. A major series of experiments was carried out on the "Salyut-7" station. For example, work was done for augmenting the panel of solar cells for increasing their power output and experiments were implemented for building supporting beam structures.

The "Ispartel" apparatus was also used on the "Salyut-7" station. It was designed for repair and restoration work in open space. Tests of a general-purpose hand tool by means of which cosmonauts will weld large structural components in space have been successfully carried out. The "Mikrodeformator" apparatus also operated on the "Salyut-7." It is necessary for study of the physico-mechanical properties of construction materials in space.

The next important step in organizing space production complexes was taken in the USSR in 1986 with the launching of the "Mir" multifunctional station. This is a station of a new generation (ZEMLYA I VSELEN-NAYA, No 6, p 2, 1986. — editor). It constitutes the base module of a multipurpose complex to which technological, scientific and economic modules can be joined

as the need arises. The construction of the "Mir" station considerably expands the possibilities for carrying out work in space for the production of organic and inorganic materials.

The "Mir" station is a step toward the construction of a long-term orbital complex. This will include a base orbital station, energy source with power of not less than tens of kilowatts, technological modules and autonomous platforms, as well as transport ships. Aboard the base orbital station there must be a laboratory for the express analysis of samples and a computer which will ensure control of the complex of technological and physical apparatus placed on both the modules and on the platforms. In order to carry out the entire complicated work program with high efficiency it will be necessary to develop the ergonomics of space production as an independent field in space mechanical engineering.

In 1987 a complex of four spacecraft ("Mir"- "Kvant"- "Soyuz TM"- "Progress") was created in circumterrestrial orbit for the first time. The length of this orbital complex is 33 m, its mass is 48 tons and the volume of the pressurized compartments is 150 m³. In the years to come, in addition to the "Kvant" astrophysical module, the orbital complex will have other modules which will make it possible to solve a considerable range of economic problems.

Thus, the work in the field of space technology which has now been carried out in our country has laid a solid scientific and technical foundation for a changeover in future years to experimental, and then industrial production of materials in space which will have a high technical and economic efficiency. In this field Soviet technology is maintaining a leading place. Without doubt the new advances in space technology will be the next important steps in the development before our very eyes of the progressive industrialization of space in the interests of the economy, science and public health.

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Remote Sensing Technology for Cartography
18660033 Moscow PRAVDA in Russian 23 Oct 87 p 6

[Article by V. Yashchenko, Candidate of Geographic Sciences, head of the USSR Council of Ministers' Main Administration for Geodesy and Cartography]

[Excerpt] In the course of their prolonged mission, cosmonauts Yuriy Romanenko and Aleksandr Aleksandrov have been broadly utilizing a multizonal space camera, the MKF-6M, and a photographic camera, the KATE-140, for studies of the Earth from space. Similar equipment is employed also on artificial Earth satellites. All space-photography materials for long-term use are sent to the Main Administration for Geodesy and Cartography (GUGK) and to divisions of the State Center "Priroda" (nature). Here, with the aid of computers and stereophotogrammetric equipment, space pictures are transformed into topographic and topical maps for the study of Earth natural resources with the participation of topographic-and-geodetic expeditions.

More than 900 organizations of various ministries and agencies are now receiving such space information from GUGK and using it in the economy. This information is yielding an economic benefit of five rubles per ruble of expenditures.

Technology for space cartography continues to advance. With the aid of new equipment, the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research has obtained photographic materials with a resolution on the order of 5-6 meters this year. For purposes of comparison, it might be said that the U.S. "Landsat" system takes pictures with a resolution of 30 meters and France's scanning system "SPOT" has a resolution of 10 meters. It can be understood why materials from remote sensing obtained in the USSR have become much in demand in many states. The export organization "Soyuzkarta" which was created in GUGK is working broadly on export of space information.

It might also be recalled that the aerial camera KATE-140 produced by GUGK which is now on board the "Mir" station in space makes it possible to obtain space pictures covering an area 450 kilometers wide at a flight altitude of 340-350 kilometers. Each exposure made from space is 180 x 180 millimeters in size. Yuriy Romanenko, Aleksandr Laveykin and Aleksandr Aleksandrov used this camera to take pictures of a portion of Antarctica. Using space pictures, GUGK is now compiling topographic maps of this continent on a scale of 1:200,000. Such maps simply cannot be made on such a scale by other methods.

FTD/SNAP /9738

Determining Bioproductivity of Sea Areas From Remote Survey Data

18660069 Moscow IZVESTIYA VYSSHIKH
UCHEBNYKH ZAVEDENIY, GEODEZIYA I
AEROFOTOSYEMKA in Russian No 4, Jul-Aug 87
(manuscript received 9 Jan 87)pp 73-78

[Article by R. I. Fimin, docent, candidate of technical sciences, and V. N. Ovechkin, candidate of technical sciences, Moscow Order of Lenin Institute of Geodetic, Aerial Mapping and Cartographic Engineers]

[Abstract] In interpreting bioproductive regions using remote sensing data it is feasible to use data characterizing the reflective properties of the studied "desert" and "fertile" areas, changing in space and time as a result of migration, decomposition, anthropogenic effect, change in the ecology of plankton and the effect of pollutants. The images are interpreted by a comparison of the brightnesses of reflected radiation with available a priori information on the spectral brightness of bioproductive objects. It is feasible to predict image quality of low-contrast objects from the image contrast level, dependent on the method for discriminating the useful signal, level and spatial-temporal distribution of brightness of the backgrounds and their spectral characteristics. With such an approach it becomes possible to choose an optimal variant of a remote survey system with such a combination of the parameters of the instrumentation used and survey conditions which makes it possible to obtain the best image quality. A practical means for solving the problem is the use of multizonal scanning systems. There are a very great number of requirements on the positioning and number of spectral intervals and therefore the choice of the set of wavelengths and their number is described. Sample materials are presented demonstrating the possibility of detection of low-contrast bioproductive areas in the visible wavelength range using the results of aerospace photographic and scanner surveys. Several formulas are derived for different illumination and sighting conditions which can be used in choosing the optimal variant of survey apparatus, photographic spectral range and survey conditions under which the quality of the image will be best. Surveys of the studied areas should be repeated not less than once a day in order to eliminate the influence of a number of factors such as cloud cover, glare, details of geological structure, underwater flora and fauna on the image quality and to ascertain the peculiarities of migration of marine biological objects. Figures 2; references 4: 3 Russian, 1 Western.

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Further Improvement in USSR State Geodetic Network

18660070 Moscow GEODEZIYA I KARTOGRAFIYA
in Russian No 12, Dec 87pp 26-31

[Article by O. S. Razumov]

[Abstract] Despite all its merits, the USSR astrogeodetic network was constructed solely for solution of problems in static geodesy. Now it is impossible to ignore the

gradual ageing of geodetic coordinates caused by mobility of the earth's surface, especially in seismically active regions. An improved network is needed for solving modern problems in terrestrial physics, astronomy and cosmonautics. The new network must be referenced to an inertial coordinate system using remote, even extragalactic, objects and have its origin at the earth's center of mass. The new network must be sufficiently precise and flexible so that at any given moment in time it will be possible to determine the relative position of its control points, the position of the earth's poles and nonuniformity of the earth's rotation. Only the construction of such a fundamental astrogeodetic network with a qualitatively new accuracy level will make it possible to obtain reliable information for extensive territories. Geodetic observation programs must provide for the following: organization of continuous observations at the highest accuracy at a limited number of points uniformly distributed over the territory of the USSR; implementation of periodic highly accurate measurements within individual regions of continental platforms, particularly in regions of tectonic and technogenic activity; implementation of current geodetic work on the retrieval, reconstruction, strengthening and readjustment of control networks. A two-point program is recommended to achieve the outlined goals. Virtually continuous radiointerferometer and satellite observations should be made at a limited number (9-10) of observatory stations separated by 2000-3000 km for determining the relative position of these stations with an accuracy to 0.5×10^{-7} and above. In order to make practical use of regional changes in coordinates within the limits of a continent, within the network of observatory stations it is necessary to construct a continuous vector network with an accuracy to 2×10^{-6} - 1×10^{-8} or construct a network of control points using a satellite system of the NAVSTAR type. The resources available for constructing such a fundamental network are evaluated. References: 12 Russian.

5303

UDC 551.466.82:629.78

Blocking of Benguela Current by Solitary Anticyclone: Analysis of Satellite and Shipboard Information

18660050a Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 87

(manuscript received 10 Sep 86) pp 9-14 sb

[Article by A. S. Kazmin and G. G. Sutyra, Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] Hydrophysical research on the Benguela upwelling along the coast of Namibia was carried out during the period April-June 1985 on the 14th cruise of the "Professor Shtokman." A joint analysis of shipboard and satellite information revealed the presence of a large anticyclone with a diameter of about 180 km in the jet of the Benguela Current which maintained a stationary

position for at least 1 month. Taking into account the absence of any correlation between the eddy and bottom relief characteristics, a theoretical analysis was made to clarify the physical mechanism which enables a localized eddy to block the current. The β effect has been used to explain the stationary position of a coastal flow using the model of a lens in a two-layer ocean with allowance for bottom friction and change in the Coriolis parameter with latitude, but this is applicable only to a current along the western boundary of the ocean, whereas the Benguela Current flows along the eastern boundary. Accordingly, the authors describe a blocking mechanism unrelated to the β effect. The nonstationary evolution of an individual eddy in a horizontally homogeneous baroclinic flow is examined on the assumption that the orbital velocity of a current in the eddy considerably exceeds the flow velocity. As a result of change in thickness of the baroclinic layer in the flow there is a spatial inhomogeneity in the distribution of potential vorticity associated with the β effect. Accordingly, in an axisymmetric flow the distribution of potential vorticity is not axisymmetric. The stationary position of the center of the eddy in the flow, like the movement of the center of an eddy under the influence of the β effect, is attributable to the blending of deviations from axial symmetry in the distribution of potential vorticity. The findings were based on probe data collected on a run along 27° South latitude oriented along the normal to the coast, supplemented by satellite data. Figures 3; references 6: 5 Russian, 1 Western.

5303

UDC 551.464.32:551.463.5

Use of Optical Classification of Oceanic Waters for Evaluating Relations Between Concentrations of Variable Components Applicable to Development of Remote Methods

18660050b Moscow ISSLEDOVANIYE ZEMLI IZ

KOSMOSA in Russian No 6, Nov-Dec 87

(manuscript received 23 Jun 86) pp 15-22

[Article by V. P. Leventuyev, All-Union Scientific Research Institute of Marine Fisheries and Oceanography, Moscow]

[Abstract] A quantitative estimate of the concentrations of variable optically active components (VOAC) is one of the principal tasks in remote sensing of the world ocean. There are three types of VOAC: living phytoplankton, whose quantity is characterized by the chlorophyll concentration; yellow matter; and suspended matter. Since these VOAC are for the most part of a biogenous origin, being products of individual stages in a unified process, it can be anticipated that definite correlations should exist between these components. The availability of such quantitative relations would be highly useful in solving the inverse remote sensing problem. This can be used as *a priori* information, making possible substantial narrowing of the range of possible

values of the parameters to be determined and may possibly reveal the presence of quite rigid relationships. Great numbers of measurements have been made on expeditionary ships for use in developing remote sensing methods. Some empirical relations among components have been obtained on their basis. However, such direct measurements are difficult and few have been made. Accordingly, an attempt was made to retrieve such relations among components from an analysis of traditional shipboard measurements of the optical characteristics of the water layer, especially the index of extinction of descending luminosity (such data are available for most regions in the world ocean). Using the spectral curves serving as a basis for the optical classification of oceanic waters, applying the least squares method, it was possible to evaluate such relations among the mean most probable concentrations of these components and also their variations as a function of the parameter defining the type of waters. Figures 4; references 14; 10 Russian, 4 Western.

5303

UDC 551.24:528.629.78

Use of Space Photographs of 'Meteor-Priroda' System in Compiling Small- and Medium-Scale Tectonic and Geological Maps

18660050c Moscow ISSLEDOVANIYE KOSMOSA IZ KOSMOSA in Russian No 6, Nov-Dec 87
(manuscript received 20 Aug 86) pp 23-30

[Article by T. P. Onufriyuk, Geology Faculty, Moscow State University imeni M. V. Lomonosov]

[Abstract] The article gives the results of use of space photographs obtained using the "Meteor-Priroda" system for tectonic regionalization within the eastern part of the Alps-Himalaya folded zone with arid natural conditions in the Caucasus, Middle and Near East. An example of one such photograph (at 1:10 000 000) with 91 identified elements is given as an example. Use was also made of tectonic and geological maps at 1:15 000 000 - 1:2 500 000, in some cases smaller, as well as the geological literature. The processing of these materials made it possible to compile a map of tectonic structures at 1:5 000 000. A map of tectonic structures interpreted from low-resolution space photographs is given with a key of 31 elements. The map shows blocks, folded systems and annular structures. A joint analysis of tectonic and geological maps compiled by traditional methods and their comparison with data obtained using low-resolution space photographs show that the content of such maps can be made more precise and considerably supplemented when space photographs are used. Cartographic referencing of the collected data to tectonic and geological maps of the Near and Middle East and the hypsometric map of the world indicated that the linear structures in most cases correspond to fault

systems and the annular structures have real geological significance. The fault systems, block, folded and annular structures jointly give rise to a fault framework whose structural patterns constitute an important source of information on planetary fissuring and the mechanism of recent structure formation in the region. This information is useful in preparing predictions of minerals, especially at the points of intersection of annular structures and linear fault zones, for metallogenetic and seismotectonic regionalization, and also in solving other theoretical and practical geological and geographic problems. Figures 2; references: 8 Russian.

5303

UDC 550.343.4:571.5+629.78

Study of Foci of Strong Earthquakes and Seismically Dangerous Zones From Space Photographs in Baykal-Aldan Region

18660050d Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 87
(manuscript received 23 Jun 86, after revision 27 Oct 86)
pp 34-41

[Article by A. F. Petrov and A. M. Borovikov, Environmental Preservation Section, Yakutsk Affiliate, Siberian Department, USSR Academy of Sciences, Yakutsk; Novosibirsk State University]

[Abstract] A tectonically active territory is situated in the southeastern part of the Siberian Platform and the surrounding area, where many hundreds of earthquakes have been registered. The area considered was 772 000 km², of which 338 000 km² are seismically active. There is a pressing need for detailed seismic regionalization and study of earthquake precursors. Aerospace and other methods have been used in meeting this need. The studied region is located in the Baykal rift and Aldan-Stanovoy geodynamic regions, the boundary between which is the Olekma River, marked by long faults and lineaments evident on space photographs. This area consists of ancient Archean and Lower Proterozoic deposits. The space photographs made it possible to detect an areal correlation between the epicenters of earthquakes and annular structures. A map was prepared showing annular, oval and arcuate structures and controlling seismic zones. Half the annular structure are not simple concentric systems, but complex eccentric systems. The diameters of these annular structures are from 15-20 to 50-70 km. The analysis indicated that in contrast to earlier prevailing concepts, it can be postulated that in the Aldan-Stanovoy geodynamic region the distribution of earthquakes with M greater than 5.0 is not controlled by the sublatitudinal Stanovoy fault, but by arcuate zones of faults and lineaments and sectors of their intersection. The most seismically dangerous zones in the western part of the territory are controlled by structures of the Baykal rift

zone; east of the Olekma River the most seismically dangerous zones are controlled by arcuate zones of faults and lineaments. In all parts of the Baykal-Aldan region there is a spatial paragenetic relationship between earthquake epicenters and "middle-rank" annular structures. Such findings can contribute to long-range prediction of earthquakes in this zone. Figures 3; references: 19 Russian.

5303

UDC 528.813

Interrelationship Between Brightness Temperature in Radio Range and Radiative Dryness Index

18640050e Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 87
(manuscript received 22 May 86, after revision 11 Sep 86)
pp 42-48

[Article by Ye. A. Reutov and A. M. Shutko, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow]

[Abstract] A study was made of the possibility of using the remote microwave-radiometric method for evaluating such a "nontraditional" integral parameter of the earth's surface as the radiative index of dryness. An attempt is made to use simple models to determine the interrelationship between the main radiometric parameter, brightness temperature in the radio range, and an integral natural parameter, the radiative index of dryness. The research included investigation of some theoretical aspects of this interrelationship, data from aerial and satellite microwave-radiometric measurements and possible applications of the results. The radiative index of dryness was proposed by A. A. Grigoryev, et al. in DAN SSSR, Vol 110, No 1, 1956. This index is $S = R/Lx$, where R is the annual radiation balance, x is annual precipitation and L is the latent heat of evaporation. The interrelationship between brightness temperature in the radio range and the radiative index of dryness was investigated using model computations of the mean brightness temperature values in the radio range for different natural zones. The results of aerial microwave-radiometric measurements were processed for different climatic zones and radiometric measurements from the "Cosmos-243" satellite were used in this process. These data were compared with corresponding values of the radiative index of dryness. It was found that there is a strong interrelationship between the intensity of microwave radiation of natural features and the radiative index of dryness. This finding can be used for the following purposes: evaluation of the intensity and trends of natural processes, such as expansion of deserts and swampification of areas, evaluation of conditions for growth of agricultural crops and evaluation of the results of anthropogenic effect on natural features. Among the advantages of aerospace collection of the

required information is that it can be obtained under any meteorological conditions and does not require complex processing. Figures 4; references 9: 6 Russian, 3 Western.

5303

UDC 528.7:681.3

Application of Successive Clusterization in Analysis of Multizonal Images

18660050f Moscow ISSLEDOVANIYE KOSMOSA IZ KOSMOSA in Russian No 6, Nov-Dec 87 pp 73-78

[Article by M. D. Breydo, A. N. Potapov, A. V. Shatalov and R. I. Elman, "Lesproyekt" Aerial Photographic Forest Surveying Association]

[Abstract] An algorithm is proposed for successive classification without teaching and its application for an analysis of multizonal images is illustrated. The essence of the method is the multiple use of cluster analysis for discriminating spectrally uniform image sectors and determination of their correspondence to information classes. Upon completion of each stage the identified sectors are assigned the name of the corresponding class and are eliminated from further consideration, whereas the remaining part of the image is contrasted and is again subjected to cluster analysis. The advantages of such an approach are indicated and the results of its use for evaluating the state of pine forests on the basis of spectrozonal photographs are presented. Figures 3; references: 7 Russian.

5303

UDC 681.3:528.72

Adaptive Automated System for Inventorying Agricultural Crops From Space Photographs

18660050g Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 87
(manuscript received 14 Nov 86) pp 79-88

[Article by V. V. Asmus, V. Vadas, A. B. Karasev and L. Kechkemeti, State Scientific Research Center for Study of Natural Resources; Central Meteorological Institute, Budapest]

[Abstract] An analysis of the effectiveness (from the point of view of the accuracy and cost of classification) was made on the basis of the results of numerical experiments for the identification of agricultural crops from space photographs. An adaptive system was devised which incorporates several different approaches to the classification problem. The choice of the optimal algorithm is made by the system in the teaching stage on the basis of the results of data classification. The identification system was realized on the basis of use of a specially developed data bank. The procedure of formation of teaching samples is described in detail for several

test sectors. This procedure makes it possible to take into account the spatial variability of data and reduces the influence of the subjective factor in the teaching stage. The described approach makes it easy to obtain a hierarchical structure of the classification of multizonal images when using an optimal combination of spectral channels at each hierarchical level. The identification system was tested using six agricultural crops with different numbers of teaching points for May and July photographs. Figures 2; references 10: 7 Russian, 3 Western.

5303

UDC 528.813

Use of Navigation Satellites for Radio

Illumination of Earth's Atmosphere

*18660050h Moscow ISSLEDOVANIYE ZEMLI IZ**KOSMOSA in Russian No 6, Nov-Dec 87**(manuscript received 10 Jul 86) pp 89-93*

[Article by A. S. Gurvich and T. G. Krasilnikova, Institute of Atmospheric Physics, USSR Academy of Sciences, Moscow]

[Abstract] A scheme for atmospheric radio illumination is proposed for the collection of meteorological data which can be regarded as optimal with respect to the expenditures on creation of sources. The proposed system consists of navigation satellites in combination with

a small number of meteorological satellites. The NAVSTAR navigation system is examined as an illustration of such a scheme. That system will be fully in place in 1989 and will consist of 18 satellites in circular orbits with an altitude of 20 183 km, each of which will emit signals at 1575 and 1227 MHz. The use of coherent frequencies will make it possible to exclude any atmospheric influence on radio wave propagation. Satellites of this system will be situated in six orbital planes separated by 60° in longitude and inclined 55° to the equatorial plane. In each of the six orbital planes there will be three equally distant satellites. The phase of the satellites will differ by 40° from plane to plane. The orbital altitude is selected in such a way that the period of rotation will be 11 hours 57 minutes 58.3 seconds. The meteorological satellite system would consist of four satellites in circular orbits with an altitude 870 km, period of 102 minutes and orbital inclination to the equatorial plane of 81.2°. The satellites will be in four orbits in four planes displaced 45° in longitude with a phase differing from orbit to orbit by 90°. Such a scheme would cover a hemisphere with grid squares measuring 500 x 500 km. The distribution of points would be close in density to the density of the meteorological network in Europe and the United States and would be superior to the density in the arctic regions. The use of navigation satellites as radiation sources in organizing atmospheric radio illumination would constitute an invaluable supplement to the aerological sounding network over the oceans and in the Southern Hemisphere. Figure 1; references 11: 8 Russian, 3 Western.

5303

SAGDEYEV INTERVIEWED ON PROSPECTS FOR SPACE COOPERATION

18660124 Moscow PRAVDA in Russian 29 Jun 87 p 6

Interview conducted by A. Lyutyy under the rubric "Problems Troubling Mankind", "A Glimpse into Our Future in Space"]

] [Boxed item: "Mankind will not remain forever on earth.... First timidly venturing beyond the atmosphere, he will then take control of all circumsolar space." Words uttered by K. E. Tsiolkovskiy in the dawn of space science. Not really that long ago. Observe that he was speaking about mankind, and dreamed of space serving all of the human race.

And now a different statement: "Space belongs to no one", declared several years ago the retired American Lt.-Gen. Daniel Graham, envisioning that outer space would belong to that country which proved the stronger. Recently, Graham told me, not without pride, that it was he who suggested the idea of SDI to R. Reagan in 1980. Don't you see, the retired general reiterated, the irreconcilable political and ideological differences between the USA and the USSR preclude an effective peaceful cooperation in space. Rivalry, including military rivalry, is inevitable in near-Earth space.]

[Question] Can the holders of such opinions really thwart the goal of cooperation in mastery of outer space, which is so necessary to all of mankind? With this question, I began the interview with R. Sagdeyev, director of the Space Research Institute of the USSR Academy of Sciences.

[Answer] I do not think there are insurmountable political and ideological barriers to successful cooperation among various countries in space. We already have examples of close cooperation, including that with the USA. There was the joint Soyuz-Apollo flight in 1975. Recently, Soviet and American radioastronomers cooperated successfully in the Vega project. Aerostats have been launched into the atmosphere of Venus. The motion of such extraordinary spacecraft can only be tracked with high precision by using radio antennas located on the various continents and keeping in communication. Cooperation continued during the brief, but hectic encounter with Halley's comet, when the Vega vehicles held a course toward the comet's core and then transmitted data for guidance of the European comet probe Giotto. Cooperation among ground tracking stations played an important part in this multilateral collaboration, including stations belonging to NASA.

I do not expect that the opinions expressed by Graham are shared by all the military in the USA. For example, we are presently in close cooperation with the Jet Propulsion Laboratory in Pasadena (California). Several days ago, a group of Soviet scientists returned from a conference there on prospects for exploration of the solar system. At the closing session, it was welcome to hear an

optimistic appraisal of the prospects for international cooperation in this field from the lips of the laboratory's director, also a retired general, the former chief of staff of the U. S. Air Force, Lew Allen. I believe that international cooperation in space is a subject of interest to more than just those who have very definite military plans for its utilization.

[Question] In Moscow, in April, the USSR Minister of Foreign Affairs E. A. Shevardnadze and the U. S. Secretary of State G. Schultz signed an agreement for cooperation in the exploration and use of outer space for peaceful purposes. How can this cooperation be carried out most effectively? American scientific circles, in particular, are talking of a possible joint expedition to Mars. Some think this is entirely feasible, others that it is technically impossible, due to the lack of reliable protection against the increased radiation from solar flares and cosmic rays. What do you think of this?

[Answer] The agreement is an important document. It reestablishes prospects for cooperation on a par with those which existed during the Soyuz-Apollo project. It is necessary to fill this in with new and specific details. One of the most promising plans discussed at Pasadena was the scenario of a flight of unmanned probes to Mars for comprehensive exploration of this planet and return of Martian material samples to Earth. Everyone agrees that this would help solve the troubling mystery of the origin of Mars, its geological history, and the history of water on it. Perhaps it might even throw light on the hypothesis of the existence of specific forms of life on Mars, even if only in the remote past.

As for a manned flight to Mars, as strange as it may seem, the radiation environment in space, in the flux of the solar wind, is more comfortable than that in the low circumterrestrial orbits. The experience of the lengthy flights of the orbital stations reveals that problems of protection against radiation during solar flares are solvable. The flight of an international crew to Mars would be a tremendous success for science. At the same time, most scientists hold that this should be preceded by unmanned expeditions to this planet.

[Question] As I was coming to see you, I heard English being spoken in the corridor. I was told that this was a routine delegation of specialists from the USA. Do you often receive foreign guests?

[Answer] Every day there are guests. Dozens of scientists come here. We are a kind of informal international society of space researchers. For many years now the door has been open in the USSR for international scientific experiments aboard our spacecraft. We are in active collaboration with the socialist countries, the developing nations, and even the West. Their cosmonauts have flown aboard our ships. There are other examples as well. In that very same Vega the instruments of nine nations are continuing their flight. In the Kvant module, which has begun an astronomical tour of duty,

there are scientific instruments installed from Netherlands, West Germany, England, as well as the European Space Agency. Dozens of foreign scientists are taking part in the testing of the scientific complex Phobos, which is scheduled to be launched into orbit around Mars next year, and this will carry instruments created by specialists from fourteen countries. The laws of nature governing the motion of bodies in space orbits impel the spacecraft to encircle the earth. No national boundaries exist for them. In a way, nature herself is prodding us toward international cooperation.

[Question] The just published annual of the Stockholm International Institute on the Study of Problems of Peace states that there exists a possibility of collisions due to the increasing number of microscopic fragments in space, formed for example by testing of the American ASAT antisatellite system. Isn't there already a need to talk of protecting the space environment from pollution?

[Answer] This problem will surely have to be dealt with in future. At the end of their life, satellites may continue to orbit for a long time if they are high enough up, say, 600 kilometers or more. But as the result of testing of antisatellite and other types of weapons, targets launched into space are deliberately destroyed, and instead of a single body there are hundreds, even thousands of fragments. And a collision with a fragment no bigger than several grams may cause an accident. The alarm that is beginning to be expressed on this score is perfectly understandable. Issues of prudent use of the space environment as the common property of mankind can be solved, if the political will is there. An organizational framework for their solution should also be found, such as the UN, or the World Space Organization which our country proposes creating.

Today, there are ever increasing problems which require a joint solution. I believe that our proposal for creation of the World Space Organization will be adopted, sooner or later. Outer space will have to be treated as the common property of mankind.

[Question] What practical results of space exploration are already influencing our life?

[Answer] We no longer notice that, on any given day, television programs contain portions transmitted from great distances via communications satellites. The same is true of so routine a matter as telephone conversations. Computer linkage via satellite will become increasingly more common. In time, new attributes of the existence of space technology will appear in daily life. In the near future, materials with special properties that cannot be produced on Earth will be grown in orbital laboratories. There are already promising results and even examples of practical use in this area. Also, the solution of problems related to space technology, such as the creation of heat protection coatings, occasionally brings unexpected novelties, such as frying pans with heat-resistant Teflon coating.

One could mention many such useful by-products. But the development of the prime avenues of space activity will be more successful and the extraction of benefits from space exploration will be more complete as soon as the threat of its militarization is eliminated. Space should remain peaceful, not only to protect and expand the possibilities of scientific research, but also on behalf of safeguarding life on our planet.

The words of Tsiolkovskiy, with which this interview began, are written on the wall of one of the halls of the Space Research Institute. As I left the office of Sagdeyev, I caught sight of yet another group of foreign visitors in this hall. I recalled the words: "an informal society of space researchers." True, these people, people from countries with different political systems, holding different ideological views, are united not because of force, but by the calling of their profession and their conscience. United, so that space may remain peaceful, and work for all nations, all people.

PROSPECTS FOR JOINT SOVIET - U.S. MARS MISSION DISCUSSED

18660125 Moscow KOMSOMOLSKAYA PRAVDA in
Russian 12 Aug 87 p 4

[Article by S. Leskov: "Together to Mars"]

[Text] Is a voyage to Mars by earthmen in the near future realistic? This question is debated by American and Soviet scientists, hosted by the "electronic cafe" of Komsomolskaya Pravda and a San Francisco "space bridge".

Do you recall how the famous movie director, Lev Kassil, regretted not having become an astronomer, as he had dreamed of doing? Had he done so, he then could have dedicated himself to the most intriguing enterprise in the world: the exploration of the planet Mars. And no one will venture to suggest that this is showmanship, the flaunting of one bathing in the limelight of fame. There are many others who feel as he does. Mars, the neighbor of planet Earth, located in the so-called thermal zone of life in the solar system, draws the imagination like an alluring magnet, wresting us from the now mastered orbits and powerfully absorbing us in the field of its own gravitation.

It is already past midnight. But instead of fatigue, it is enthusiasm which rules the discussion, faith in the possibility of an undertaking unheard of before. Looking at the famous Soviet academicians, scientists and space engineers in the Space Pavilion of the Exposition of Achievements of the USSR Economy, I am convinced that they, too, have fallen under the spell of the enigmatic planet. And on the other end of the "space bridge", the equally enthusiastic American astronomers and designers. Faces flash on the screen, hypotheses are formed and rejected—one gets the impression that the participants of the roundtable are not in fact separated by half a world, that they are instead sitting at the same

table. As a matter of fact, that is what will indeed happen, if today's discussion is to be continued. The discussion is about a joint expedition of the USSR and the USA to the planet Mars.

Before continuing to talk about the project, we should respond to the question that the proponents of national scientific priorities will not fail to ask: why in fact a joint expedition? With a little effort, one could be the first to race to Mars. Let us look at our capabilities soberly. For success, we must take firm hold of all that is progressive in science and technology around the world. Some things we do better, other things, someone else. There is no alternative to collaboration in this matter.

There have been bright times for cooperation, and there have been dark. But recently, as the chairman of the President's Commission on Space, Thomas Paine, reminded the participants of the space bridge, the agreement for bilateral cooperation in space covering 16 areas was revived by Secretary of State G. Schultz and Foreign Minister E. A. Shevardnadze.

In science there is quite a wealth of tradition involving prying into the secrets of Mars. If you browse through old newspaper accounts, you will find that the whole world at the turn of the century was astir with the sensational observations of the Italian astronomer Schiaparelli, who had discerned a branching network of canals on Mars. The public fancied the hand of the martians here: fellow creatures! The newspaper which failed to offer an "astronomical" column would be faced with bankruptcy. It does not appear that any such thing had ever occurred before in the history of science. Uranus, the imperturbable muse of the astronomer, had never before excited such fervent popular interest. The most thorough advocate of the artificial canals theory was the American Percival Lowell. At his own expense, he constructed a special observatory in Arizona, calculated the rate of flow of water through the canals, and created a heart-rending picture of the dying Martian civilization.

Given our present knowledge about Mars, we can but smile at the pronouncements of Lowell. But let us not be harsh with the romantics. Their role in the advancement of science and the awakening of public interest in it still remains to be studied. In this respect, the Soviet scientist Fridrikh Tsander may be called the "alter ego" of Lowell. His passionate appeal "Onward, to Mars!" became a popular expression. Literary historians say that Aleksey Tolstoy's hero, Engineer Los from the story "Aelita", is largely patterned after Tsander. Just as (in my honest opinion) the first in the series of Soviet Mars satellites, were designed and sent to the red planet under the leadership of S. P. Korolev, who remained true to the dream of his friend. And already seven Soviet satellites have been sent to Mars—a regular flotilla.

The American stations of the series Mariner and Viking have also flown to Mars and made landings on the surface of the planet. But these were isolated missions,

not tied together in a carefully thought-out program of comprehensive exploration of the planet. The scarcity of information has lent itself to the construction of the most whimsical models. I still have 20-year-old clippings from "Tekhnika—Molodezhi" praising the astrobotany, or science of Martian vegetation, developed by the excellent scholar G. A. Tikhov on erroneous suppositions. Even today, there are still only isolated green spots in the planetology of Mars and whole untouched continents waiting to be examined in earnest.

In 1969, intoxicated with the success of the lunar mission, the USA under the direction of Werner von Braun began work on Project Nerva, envisioning a manned mission to Mars. Hundreds of millions of dollars were spent, but the level of technology necessitated giving up the tempting idea. All that remained was the abandoned site in Nevada, which unkind wags disrespectfully dubbed "the field of blockheads."

But however much the sceptics scoffed, they could not daunt the believers in a Martian expedition. Last year, the American professor Carl Sagan, whose reputation in scientific circles is very high (in particular, he was the scientist in charge of the Viking program), appeared in the magazine "Parade" with an article proposing a joint expedition of the USSR and the USA to Mars. The present space bridge was largely born on the wave of success of this article. And now one can witness in person how ardently Sagan defends his arguments. Decades ago, says the professor, Mars beckoned to the founders of cosmonautics, Konstantin Tsiolkovsky and his American counterpart Robert Goddard. The rockets on which they worked were intended not to destroy life on Earth, but to carry man to the other planets and stars. The scientist mentions a date when work might begin on a joint expedition—1992. A jubilee year for both countries. The five hundredth anniversary of the discovery of America and the seventy-fifth of the October Revolution. A manned flight, the professor believes, will become technologically feasible by the beginning of the twenty-first century.

Scientists have taken up the appeal of Sagan. How could there have been any doubt? By all means, fly! And if an expedition is not yet possible today, now is exactly the time to be planning and developing it so that it may be possible tomorrow. Meanwhile, complete unanimity in an unheard-of venture would have been suspicious. Just so, there was an unbeliever in our pavilion, none other than the famous science fiction writer Arkadiy Strugatskiy. Listening to his rebuttals, it occurred to me that what is most characteristic of a fiction writer might not be unthinkingly bold projects, but rather a nontraditional thinking, an ability to see a problem in a different light. It also occurred to me that the scientists in their dry theories often outstrip the untrammelled flight of the writer's imagination, and even if we do think differently the fault lies with the closed nature and inaccessibility of scientific formulations. But however this may be, Strugatskiy spoke on matters by no means frivolous.

"Yes, I am a pessimist. Given the present state of the economy and the social conditions, it is too early for scientists to attempt such enormously expensive project. First, we must agree on closer cooperation on Earth and correct the situation where a good half of the human race thinks of nothing other than their stomach growling for food. For now, the space program should be confined to the region around Earth. A flight to Mars is not worth the trouble. We would have to cross around 200 million kilometers, and it is anyone's guess how long we would have to stay on the planet, waiting for a propitious moment to return. The engines are too weak, you can't go far on chemical fuel. It is necessary to create materials affording maximum protection to the people and the instruments on such a long journey. Energy-storing superconductors are a must. Until such things exist, I am a strong opponent of any long term Martian program. Even without this, the budgets of our countries are quite strained."

The scientists quickly leap to the attack on Strugatskiy, and he regards his incensed antagonists with such curiosity that I half suspect this student of the human mind is teasing the experts to draw even more out of them. Astronaut E. Aldrin, who has already walked on the moon, and Cosmonaut V. Kubasov, member of the Soyuz-Apollo Mission, appeared especially offended on behalf of Mars. To the space voyagers, the expedition is a personal, deadly serious business.

The discussion revolved around four main points. Why, indeed, should man go to Mars, what is so important that he expects to find in the far reaches of space? What studies are to be done on Mars and how should they be organized? How and by what means can the red planet be reached, and how to return? Is it medically possible for a human to withstand such lengthy stay in outer space? So many questions! The problem of an expedition to Mars is like a mountain lake, from which there flow several streams, which in turn branch off into babbling brooks and creeks, forming a very tangled network encompassing nearly aspect of human knowledge.

Well then, why? Mars may bring inestimable benefits to science and to all humanity. In the opinion of V. Barsukov of the Academy, the study of Mars is the key factor in understanding the evolution of the earthlike planets. Why did rivers formerly flow on Mars, and why is the entire surface now wrapped in permafrost? Where did the oxygen go, in which the Martian atmosphere probably abounded? Why did the climate change drastically on Mars? What is the origin of the gigantic volcanoes, the like of which do not exist on Earth? Where did the thousand-kilometer crevices come from, pitiless scars disfiguring the face of Mars? Sand storms reaching half the speed of sound, mountains with geometrically regular outlines of pyramids, bright spots on the surface... The answer to these and dozens of other riddles will enable a glimpse into the future of Earth. It is best to learn of that which threatens your own house from that of your neighbor.

But let us not beat about the bush. The reason why Mars and an expedition to it enjoy such invincible popularity is, of course, the question of life on the planet. Every schoolboy knows that, in the solar system, it is Mars which can lay claim to being a hothouse where life is fostered. It would appear that, after the touchdown of the two American Viking stations on the planet, the hopes crumbled to dust. Not only did no one emerge to greet the landing modules, no footprints were found, no flimsy vegetation of any type, no remains of the hypothetical civilization. Not even a rudimentary organic molecule. It was a barren crypt. But there is still a great desire to find be it only a bug of some sort, or a tiny mite, in the universe. Incidentally, the director of the biological experiments in Viking, G. Klein, believes that we were hasty in declaring Mars "lifeless." It is necessary to search better, to select a more accurate sampling location. Life may exist in the dried-up lakes beneath the surface of the planet, or inside the Martian soil, according to L. Mukhin and H. Masurskiy.

But how to look for life? V. Barsukov is correct in saying that a manned flight into the unknown is too great a risk, too high a price. But, on the other hand, M. Ivanov and Professor S. Squires are correct in saying that only a human being personally witnessing the planet with his own eyes can understand the Martian magic in its entirety.

In this connection, the proposal of V. Moroz and E. Ingersoll is interesting. Why not combine the forces of man and robot in the expedition? A team of specialists in a laboratory flying above the surface would control robot-manipulators, and these would penetrate into the most dangerous regions fearlessly and beyond reproach. V. Linkin, creator of Venusian probes, remains true to his metier: he has already begun work on "jumping" Martian balloons for the launching of the Soviet automatic Mars probe in 1992. K. Sukhanov produces drawings of a Martian rover, very similar to a dune buggy. This is matched by R. Kell. The designers jealously compare machines. Which is better? It will have to come to testing.

Can robots discover much? Much, but not all. The environment of Mars is suitable for a cosmonaut (in a spacesuit, of course). And, obviously, after the initial exploratory phase which can be entrusted to the robots, man will himself have to make a descent, if he wants to lay out the secrets of Mars in detail. And there will always be a risk. There has never been a case when the first discoverers were not at risk.

It is another matter as to whether the human being is medically able to withstand a prolonged (9 months in one direction alone) space journey. And if so, what sort of person should this be? In the USSR, many cosmonauts have completed lengthy orbital flights. There is no such experience in the USA, and Professor P. Rambo is

concerned about the weight loss, the influence of long-term weightlessness on the skeleton and on the circulatory system. Professor A. Ushakov is certain: the preventive and adaptive measures worked out for weightlessness make such flight possible. However, such eminent authorities as Professor L. Friedman and Member of the Academy O. Gazenko are less optimistic: it is too early for a guarantee, careful studies are necessary.

Next, by what means to fly to Mars? Another problem. Quite obviously, none of the presently available booster rockets can "make it." Proton, Titan, the Shuttle are weaklings when it comes to Mars. The best minds of the Soviet Automatic Space Vehicle Center and the American Jet Propulsion Laboratory have set to work: R. Kremnev, G. Ragovskiy, O. Popkov, L. Friedman, D. French, R. Burke. One thing is clear: several vehicles are needed. The functions in the international Martian armada may be distributed thus: one side will take care of the trip to Mars and the landing of the orbiter, the other the return voyage. Perhaps a way station should be built on the moon? Or large space cruisers be assembled in orbit? Or place a base in Martian orbit?

Still, what about the arguments of A. Strugatskiy, that there is still a whole host of problems on Earth, and that these are far more important than interplanetary wild goose chases? We shall leave aside the fact that the cost of developing the new technologies and designs would be recouped many times over, after universal adoption on Earth. But are the funds really being used to best advantage today? In the words of Member of the Academy R. Sagdeyev, the cost of the project is half that of the anticipated expenditures of the United States on SDI up to the year 1993. C. Sagan agrees: at the present level of development of science, an expedition to Mars would even be cheaper than the flight to the moon 20 years ago.

But still, why to Mars? In at least one point, I personally cannot fail to agree with Strugatskiy. On our planet there are sufficient problems requiring common efforts of the nations. And these problems are so severe that a concern about them can hardly be called Earth-centeredness. But the realities of our life on Earth are such that, frankly, it is perhaps easier for the USSR and the USA to agree on a flight to an uninhabitable planet, than on how to feed the starving of Asia and cure the sick of Africa. Cooperation on Earth, for the moment, is more unreal than cooperation in space. But couldn't it be possible to find a common language in just such nonearthly and infinitely less painful endeavors, and to begin to speak in this on the old planet Earth? Such a course is feasible, and it is tempting.

In the end, did the scientists change the mind of the unbelieving writer, A. Strugatskiy? I do not know. But judging from his satisfied smile, the crafty writer found out much that was interesting.

Barsukov Interviewed on Soviet Mars Program, Prospects for U.S. Cooperation

18660045 Moscow IZVESTIYA in Russian 8 Dec 87
p 3

[Interview conducted by B. Konovalov, Izvestiya science reviewer, with Valeriy Leonidovich Barsukov, director of the Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Corresponding Member of the Academy: "We Are Flying to Mars"; dual dateline—Brighton and Moscow; lead beneath title reads: "A conversation with the director of the Institute of Geochemistry and Analytical Chemistry of the USSR Academy of Sciences, Corresponding Member of the Academy, V. Barsukov, on the plans for the study of Mars"]

[Text] **Question** Valeriy Leonidovich, Mars has become a "star of the first magnitude" on the horizon of today's cosmonautics, and the attentions of scientists in most countries has become focused on projects involving the study of this planet in particular. How do you explain that?

Answer In size and mass, Mars occupies an intermediate position among the Moon, Venus, and the Earth. It is the most important link for providing coherence to the evolution of planetary bodies, from the primitive geology of the Moon to the more complexly structured Earth. This very notion, as well as the probability that simple forms of life existed there in the past, explains the rapidly growing interest in a detailed study of Mars.

Mars has an atmosphere, albeit rarefied by comparison with Earth's. It used to be more dense. The planet's climate has changed. There was a warmer period of time in which water existed on the planet's surface and rivers flowed. And water, as we are accustomed to think, is life. And it is entirely possible that some kind of early forms of life could have evolved on Mars. Whether or not life exists now is hard to say. But we cannot exclude such a possibility. It could be preserved from the past in places that have retained rather substantial heat from the crust of the planet.

The fact that nothing has been found at the landing sites of the two American Viking spacecraft is not proof of the absence of life. In the first place, the sites were randomly chosen spots. Besides, one would least expect to find life on the surface. And in the second place, the search technique itself was not very thorough. In Antarctica, for example, it is practically impossible to detect biological activity with a single probe in one spot. But if a sample that is taken is kept in heat and microbes are allowed to grow into a vigorous colony, then life can be identified. We now know that life nevertheless "burns low" in Antarctica, in spite of the severest conditions, conditions that are the most similar to those on Mars. Therefore, it cannot be ruled out that even on Mars we may find some kind of primitive forms of life.

For that reason, one of the primary goals of both our and the Americans' long-range plans is to deliver samples of the Martian soil to Earth and to study that soil with a whole arsenal of the most advanced scientific means.

Question That is a complex task. Apparently, it would be difficult for us to work things out all at once by rushing headlong into the matter, and a tremendous amount of preliminary work is needed. What stages do scientists plan in the study of Mars? Are there any substantial differences between our plans and those of the Americans?

Answer Both we and the Americans plan to launch in the early 1990s, as a first stage, Martian satellites that will conduct global studies of the planet. What kind of scientific equipment will be needed for this and whether this research will be done in one stage or in two stages are under discussion right now.

It is clear that several scientific complexes must be on board. To begin with, an optical complex. It will make it possible not only to receive television images, but also to study the atmosphere. It will be very interesting to analyze the ratio of the various hydrogen isotopes in the Martian atmosphere, because it will enable us to decipher the history of water on that planet and to determine how much was there before. Studies in the optical range will make it possible to determine the mineral composition of the surface rock.

Surface analysis data compiled by the two American Viking spacecraft, whose landing sites were four thousand kilometers apart, turned out to be absolutely identical. And that is not surprising. Dust storms rage on that planet for four months, by Earth measure, and two months, by Martian measure. The entire surface is covered with dust that is so well blended that all differences are obliterated.

In order to be certain that you are studying bedrock, you must go deep, beneath the build-up of the "oxidized zone and the weathered layer." For that reason, there must be on board the Martian satellite an advanced mass spectrometer that will provide information on the composition of rock from the surface to roughly a meter's depth.

An on-board longwave radar unit would make it possible to illuminate the surface roughly up to a kilometer wide and to determine the extent of the dust layer and find the places where the bedrock is at a depth of less than a meter, which is very important for subsequent drilling. Simultaneously, we would learn the "geography" of the permafrost on Mars. From its position, we would be able to estimate the rise of deep-seated heat. Regions with higher thermal flux could turn out to be of interest in terms of a more detailed study of biological and paleontological activity.

Side-looking radar would be useful for obtaining a detailed picture of the relief and location of ancient river valleys hidden by dust deposits and of surface irregularities. That is necessary both for choosing landing sites and for ensuring the safety of the landings.

The operation of all the satellite's complexes will provide us a large number of the different types of maps that are needed for subsequent stages of the study of Mars and for a sound choice of sites for collecting samples that will meet the requirements of specialists such as geologists, geochemists, biologists, and climatologists.

Question At the Moscow Space Forum and at the most recent congress of the International Astronautical Federation in Brighton, there were discussions of the possibility, along with developing Martian satellites, of launching aerostats into the Martian atmosphere much the way it was done in the Venutian atmosphere.

Answer That is absolutely correct. However, it is being suggested that instead of using aerostats like those used on Venus, which were simply carried to a great altitude by the wind, we use guided or self-guided aerostats. By expanding or contracting the envelope of the aerostat or balloon, as the Americans prefer to call them, we can regulate the altitude of flight. Moreover, we can produce a so-called double aerostat in which the warming atmosphere of Mars itself induces a considerable portion of the lift. This aerostat will rise to a given altitude in the morning, fly there during the course of the day, and then land in the evening and spend the night on the surface.

This makes it possible to solve not one, but three problems at the same time. As on Venus, a weather complex can be used to study atmospheric dynamics. In addition to this, during the rise and the descent, the aerostat's miniature television cameras enable us to produce an image of the Martian surface from the altitude of the "flight of a bird," with an extremely good resolution that is hard to achieve from satellite orbit. We can outfit the aerostat with a light gamma/x-ray spectrometer that will enable us during the aerostat's flight as well as upon its landing on the surface to obtain data on the chemical composition of the rock. In 6 to 10 days of flight, the aerostat would travel several thousand kilometers. Other instruments can be used, too.

Question: Does that mean that the next stage is already landing on the surface? What regions are of the most interest, and how do scientists intend to study them?

Answer Yes, all the subsequent stages already include the landing of descent vehicles on the Martian surface as a mandatory mission component. As regards the choice of regions for detailed study, that is such a complex matter that today it would be difficult to give you a clear answer. Right now, our scientists and engineers are working on this matter with American specialists intensely. It is a very complex question. The interests of various scientists and fields of study sometimes impose mutually

exclusive sampling requirements. A whole series of technical requirements set forth by the engineers who develop the spacecraft must be considered. All this must somehow be integrated.

We are, of course, very interested in regions showing the development of the ancient, original Martian crust. We are attracted to the polar caps, in which the history of the climate and the atmosphere's evolution is "written." Of great interest are the former river valleys of Mars. The whole of the evolution of the Martian climate is enciphered here in the sedimentary rock, and life may exist in some form or another. It is also necessary to trace the history of magmatism on Mars. There are volcanoes there that were active for more than 600 million years. They carried out huge amounts of lava from the planet's interior. Eruption after eruption occurred. It is important to find out how the composition of the lava changed in this process. It would give us a great deal of data on the history of the interior life of the planet.

As you can see, this involves a great many tasks, and accomplishing it can be done only with a Martian rover equipped with advanced instruments for studying and collecting the needed samples. The same collective that developed the world-famous lunar rovers is working on it right now. At the same time, the Martian rover will make it possible to make a large series of panoramic photographs. It is already clear that samples will have to be collected over a large area, and for that the rover will have to cover several hundred kilometers. Initially, it could perform vibrational sounding [vibroprosvetivaniye] of the interior of Mars in order to determine its internal structure.

This same rover with collected rock samples could also serve as a radio beacon at a site it chooses that would be suitable for a lander equipped with a rocket for delivering cargo into Martian orbit. There the rocket would dock with the satellite, where the collected samples would be transferred to a return rocket that would go to Earth.

As you can see, the project is complex, almost fantastic, but by the end of the century it may nevertheless be accomplished with the collectives who will bring about the development of cosmonautics.

Question Valeriy Leonidovich, how will the problem of studying the Martian soil here on Earth be resolved? Why, you said that they may contain extraterrestrial microorganisms. Their spread could have horrible consequences much worse than AIDS.

Answer Of course, that must be taken into consideration. The return rocket with the Martian soil must be intercepted in near-Earth orbit. A preliminary study of the soil can be performed in orbit. And only after scientists

are sure that either there is no biological activity in the samples or that it can be handled at any moment, the Martian "parcel" can be delivered to its Earth receiving laboratory.

Question The plans that you have described are complex and expensive. To what degree will their execution involve international cooperation, and in particular, collaboration between the United States and the USSR?

Answer Practically all of our space research right now is being done with broad-based international cooperation. The Martian program will be no exception. We are already collaborating in its preparation with socialist states and other countries such as France and Austria. As regards the United States, for now the Soviet Martian research program and the American research program are being developed independently, with some coordination. There is hope for a definite collaboration. With the "glacial" period of relations ending, there is a "warming" now. Talks have begun on collaboration in space in several fundamental areas. The first Soviet-American working meeting on planetary research takes place in Moscow from 7 to 12 December.

We are very hopeful that General-Secretary M. S. Gorbachev's visit to the United States will strengthen the positions of new thinking on our planet, including in the United States, and will facilitate the strengthening of scientific and technical collaboration.

Of course, even just from the standpoint of common sense, the most advisable thing to do would be to make the Martian program international, for all men, and to combine the efforts of many countries. Indeed, all of mankind has a stake in the study of that planet. Every human being has a stake in the detection of Martian microorganisms not turning into disaster. For that reason, of course, it would be much better and even fairer if the reception of Martian soil were to be by an international laboratory and if the finest scientific people on the planet were enlisted to study it.

And when this mission is accomplished, the path will be cleared for performing an even more complex mission, long a common dream of man—the flight of a crew of earthlings to Mars. I am confident that, whatever the obstacles that stand in the way right now, the crew to Mars will be international.

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Barsukov Stresses Importance of U.S.-Soviet Cooperation in Planetary Programs

18660091 Moscow SOVETSKAYA ROSSIYA in Russian 13 Dec 87 p 2

[Article by A. Nemov and A. Cherkudinov]

[Excerpt] The concluding documents of the meeting of the Soviet-American working group for research on the solar system have been signed in Moscow.

V. Barsukov, corresponding member of the USSR Academy of Sciences, director of the academy's Institute of Geochemistry and Analytical Chemistry and head of the group on the Soviet side, said:

"Mutual coordination of Soviet and American space programs for study of planets of the solar system is now simply essential. For example, we have turned over to the American scientists a complete set of maps of the surface of Venus which were obtained with the aid of our 'Venera-15' and 'Venera-16' stations. They will play a part in preparations for a flight of unmanned stations of NASA to the planet Venus which is to take place in 1989, within the framework of the 'Magellan' program. On the other hand, details of the final draft of our 'Phobos' program will be worked out with the aid of photographs of Mars which U.S. colleagues have turned over to us. Exchanges of this kind will permit savings of both effort and money."

"Our agreement calls also for closer interaction between the two countries. American scientists will be enlisted in analyzing results of flights of unmanned Soviet stations which will leave for Mars in July of 1988. And Soviet researchers will take part in an American program, 'Mars Observer,' in 1992."

"Achieving the ultimate goal of the first stage of the Mars study—delivering Martian soil to Earth—will require a substantial amount of preliminary work, particularly development of an engineering model of Mars (models of its surface, atmosphere and gravitational field), studies of its surface from orbit and, lastly, landings of automatic equipment on Mars."

FTD/SNAP 08309

Deputy Director of IKI Discusses Upcoming Space Missions

18660093 Moscow KRASNAYA ZVEZDA in Russian
3 Jan 88 p 4

[Article by V. Balebanov, deputy director of the USSR Academy of Sciences Institute of Space Research, USSR State Prize laureate]

[Abstract] The article surveys space-research events which are planned for 1988. The author hails continuing expansion of Soviet collaboration with foreign specialists in this field, noting that the USSR Academy of Sciences' Institute of Space Research has established contacts with chief scientific research centers of Denmark, Belgium and Brazil and is discussing possibilities for cooperation with centers of a number of other countries.

Spacecraft scheduled for launching this year are said to include a space observatory, "Gamma-1," and a satellite of the "Astron" type with an onboard observatory called "Granat." The author relates that "Gamma-1" will carry instruments for measuring flows of gamma ray quanta with tremendous energies. This will make it possible to

study hard gamma radiation and thermonuclear-explosion processes in distant celestial objects. French and Polish scientists are taking part in the "Gamma-1" project. The "Astron" spacecraft's onboard equipment will include a telescope which was built in France for studying soft gamma radiation of the universe, two Soviet telescopes for studying hard X-radiation, and instruments for studying rapid bursts of gamma radiation and X-radiation. Scientists of Bulgaria and Denmark are also taking part in this project.

The author notes that the next specialized research module for the orbiting station "Mir" is supposed to be launched in 1988. This module, which will be equipped with a video computer, is intended for studies of the Earth, its atmosphere and the world's oceans. Scientists and specialists of the USSR, Czechoslovakia, East Germany, Hungary and Bulgaria are preparing equipment and experiments for the module.

The author comments also on a project called "Aktivnyy," which is to be conducted within the framework of the "Intercosmos" program. This project will involve research on processes of energy transfer from the sun to the Earth, particularly studies of phenomena produced by the action of electromagnetic waves on plasma in the ionosphere, the author relates. A special satellite in a low circular orbit (300-500 kilometers) will be used in the "Aktivnyy" experiments. A smaller satellite built in Czechoslovakia will separate from this "mother" satellite. This will make it possible to measure phenomena of interest from controlled distances, the author explains. Measurements will be made at two points in space which are in the same orbit. The "Aktivnyy" project calls for another satellite to be launched in 1989. This spacecraft is to be used in an experiment, "APEKS," for studying mechanisms of solar-energy conversion in the ionosphere. Effects produced by flows of plasma and electrons will be studied in the course of "APEKS" (an acronym of "active plasma experiment").

FTD/SNAP 08309

Press Conference on Upcoming Soviet-Bulgarian Mission to 'Mir'

18660092 Moscow KRASNAYA ZVEZDA in Russian
26 Dec 97 p 5

[Article by N. Zheleznov, correspondent]

[Excerpt] Bulgarian pilots Aleksandr Aleksandrov and Krasimir Stoyanov, who saw the new crew for the "Mir" station off into space on 21 December, will meet them in orbit in June of 1988. At a meeting with Soviet and foreign journalists which took place in the press center of the USSR Ministry of Foreign Affairs on 25 December, Aleksandrov and Stoyanov told about preparations for the second Soviet-Bulgarian space expedition and reported on the research program of this mission.

Taking part with the Bulgarian pilots in this conversation were A. Solovyev and V. Lyakhov, commanders of the crews that are preparing for the mission, and V. Savinykh and A. Zaytsev, the flight engineers.

The Soviet-Bulgarian crew will be the first such international contingent on the "Mir" station. Participants in the press conference recalled that the first Soviet-Bulgarian expedition, which took place in April of 1979, lasted only two days.

A. Leonov, deputy head of the Cosmonaut Training Center, emphasized that the upcoming expedition can by no means be considered a "consolation mission," to borrow an expression from sports. B. Bonev, a Bulgarian professor and head of the research program, supported this idea with specific examples. Nine sets of the latest equipment are being readied for the mission. About 40 geophysical, medical, technological and astrophysical experiments will be conducted with the aid of this equipment. Bulgarian engineers have developed a new class of remote-sensing equipment that is distinguished by high resolving power, and also new-generation equipment for creating new alloys and materials in conditions of zero gravity. The first onboard personal computer will be another innovation in international expeditions. This computer will make it possible to conduct preliminary processing and analysis of results of experiments directly in the course of a mission.

FTD/SNAP /08309

Agreement Signed on 1989 Soviet-Afghan Space Mission

18660034 Moscow IZVESTIYA in Russian 1 Oct 87 p 6

[Article by B. Roshchin]

[Text] An official agreement in regard to a joint Soviet-Afghan space mission was signed in the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos) on 30 September. A memorandum was signed by Muhammad Aslam Watanjar, member of the Politburo of the Central Committee of the People's Democratic Party of Afghanistan, Afghanistan minister of communications and head of a delegation in charge of preparing the joint mission, on the Afghan side; and by Aleksandr Ivanovich Dunayev, head of Glavkosmos, on the Soviet side. Muhammadullah S. Safi, Afghanistan ambassador to the USSR, attended the ceremony.

"We are very happy that friendship between our peoples has reached space altitudes, so to speak," emphasized M. Watanjar.

Selection of candidates for the upcoming mission will soon begin in Afghanistan. Two Afghan candidates will begin training at Star City early next year. It is planned to conduct the joint space mission during the first half of 1989. FTD/SNAP /9738

Soviet-French Meeting Discusses Joint Space Projects

18660035 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 23 Oct 87 p 3

[Article by A. Sorokin, correspondent (Paris)]

[Excerpt] The 24th annual Soviet-French conference on cooperation in the field of space research has taken place in the French city of Trouville-sur-Mer. A wide range of questions connected with future joint steps of the USSR and France in the field of peaceful exploration of space was discussed in the course of this conference.

The question of preparations for the second joint Soviet-French manned space mission held a special place in the conference's work. This mission is planned for November of 1988. In the course of it, one of the two French cosmonauts who are now training at Star City—Jean-Loup Chretien or Michel Tognini—will spend a month on board the orbiting space station "Mir" with Soviet cosmonauts. Plans call for a Soviet and a French cosmonaut to make a joint egress into open space for the purpose of attaching specimens of a new composite material called "Era" to the outer surface of the station.

Among the other topics discussed at the conference were questions of the compatibility of docking mechanisms which the European Space Agency is developing for the reusable spaceship, "Hermes", and for Soviet orbiting space stations, and also questions of completing preparations for carrying out project "Phobos". Of much interest are programs called "Gamma-2" and "Granat", in which French scientists will also take part. Research on supernovae whose radiation has been recorded by X-ray telescopes of the Soviet orbiting station "Mir" is planned within the framework of these programs.

A press conference on results of the visit took place at the National Center for Space Research. At this conference, A.I. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos), emphasized that the meeting as a whole took place in a business-like and constructive atmosphere and was accompanied by open discussions. FTD/SNAP /9738

International Conference on Project 'Interbol'

18660040 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 28 Nov 87 p 2

[TASS Report]

[Text] Suzdal (Vladimir Oblast), 27 November. A large-scale scientific project called "Interbol", which is planned for the early 1990s, is taking shape more and more definitely. Preparations for this project were the topic of an international scientific-technical conference which ended here today. Taking part in the conference were more than 150 scientists and specialists from the

Soviet Union, Bulgaria, the German Democratic Republic, Cuba, Poland, Czechoslovakia, Austria, Canada, Finland, France, Sweden and the European Space Agency.

"A number of complex scientific and technical questions were examined at the conference," noted Professor A. Galeev. "Methods of conducting research were also examined, and principal tasks of the experiment were defined. The purpose of the experiment is to study plasma and electromagnetic fields in near-Earth space."

P. Triska, a Czechoslovak scientist and one of the leading participants in the project, emphasized that it is arousing widespread scientific interest in various countries. Professor L. Cogger stated that Canadian scientists who are developing equipment for obtaining images of the structure of polar auroras regard participation in the "Interbol" project as a unique opportunity for conducting coordinated studies of processes which give rise to magnetic storms and auroras.

FTD/SNAP 9738

Status of Plans for Vesta Project
18660060 Moscow IZVESTIYA in Russian
2 Jan 88 p 2

[Article by B. Konovalov, science correspondent of IZVESTIYA: "Project Vesta"]

[Text] The Soviet Union, France, and the European Space Agency (ESA) are presently carrying out joint preparations for project Vesta, the implementation of which would allow a detailed exploration of several asteroids and one of the comets.

This project is the direct offspring of the "Venus-Halley's Comet" expedition, or "Vega" for short, during which the scientists learned that the old Russian proverb: "If you chase after two hares, you won't catch either one" does not apply in matters of space. Here, it is advisable to have several goals for each mission, which greatly enhances the scientific value. On the other hand, the success of project Vega is yet another brilliant demonstration of the fruitfulness of widespread international cooperation in space explorations that are important to all of humanity.

At the moment, the first draft of the Vesta project is being worked out. It is not yet clear which asteroids and comet will be explored. This will depend on the launch date. This is tentatively scheduled for the beginning of the 1990s. Possibly this expedition will be combined with the flight of a Soviet spacecraft to Mars, in order to use only one rocket. Constraints are also imposed by the fact that penetrators, or devices for detailed investigation of the ground of the celestial body at the landing site, are to be dropped on one of the asteroids. It is being proposed to send two earth "prospectors" to the asteroids. Ballistic calculations of possible flight versions are

being done concurrently in Western Europe and the Soviet Union. Already today, these developments make up a sizable tome, and the search for the optimal alternative is continuing. The work is complicated. Therefore, the scientists cannot yet give the exact "destinations" of the routes.

Clearly, the objects of the detailed investigations should be relatively large bodies with diameter of more than a hundred kilometers, so that they can be located easily enough. It was originally proposed to study the two largest asteroids, Vesta and Ceres, in detail. The diameter of the planetoid Vesta (in Roman mythology, the goddess of the hearth) is more than 300 kilometers, while that of Ceres (the Roman goddess of farming and fertility) is around 1000 kilometers.

The astronomers know that Vesta is a rather bright formation, while Ceres is one of the darkest in the so-called main asteroid belt. This belt extends between Mars and Jupiter, and apparently the asteroids are the material of a planet which never formed. The strong attraction of the gigantic Jupiter, which by the way is often called an unformed star, did not allow the asteroids to gather into a compact planetary body. Evidently, they consist of the primordial substance from which the planets of our solar system were formed, and therefore are of immense interest to science.

I questioned V. L. Barsukov, director of the Institute of Geochemistry and Analytical Chemistry of the USSR Academy of Sciences, and Professor Yu. A. Surkov, the leading planetologist of this institute, as to the scientific importance of the Vesta project. They believe that, at the present stage of development of cosmonautics, an understanding of the preplanetary stage of formation of our solar system takes on primary importance, and this requires an investigation of the asteroids and comets. "The recent study of the moon, Venus, Mars, Jupiter, Saturn," they declare, "have already allowed us to gather an immense volume of information. We understand how these bodies were formed and how they evolved. But the history of their evolution from the stage of an already formed body down to the present day is known best of all. What came before that is virtually cloaked in a mist of obscurity. The long held beliefs are often not borne out by practical verification. For example, it was believed that the differentiation of matter and the separation into layers occurred on the planets only after sufficient heat had been built up, generated by the decay of radioactive elements. Today, scientists incline to the belief that the formation of the core of the celestial body and the primary crust took place from the very outset during the impacting of large chunks as the planet was 'coalesced' and heated by the collisions. Studying the planets, it is difficult to discover what was the original unmodified substance from which the solar system was formed roughly 4.5 billion years ago. But the comets, asteroids, and meteorites may provide this information. By studying them, we might understand and reconstruct the earliest history of our stellar home." Obviously, this

material was diverse in composition: the further from the sun, the more volatiles, and vice versa. Therefore, the small celestial objects should be explored in a systematic and protracted manner, in order to discover the distribution of substance in composition and density in the vicinity of the sun during the earliest epoch of formation of our planetary system".

Listening to the scientists, I got the impression that the Vesta project was a kind of time machine. And the flight of the two spacecraft, which are to be created by the joint efforts of various countries, is a voyage into the past of the solar system, when the planets were only just being born.

At the moment, the international division of labor in the Vesta project is as follows. France and ESA are developing their own spacecraft. The Soviet Union is cooperating with them in developing the scientific apparatus, will make available the launch rocket, and is making the onboard penetrators which are to "land" on the asteroids and carry out detailed investigations. The final decision as to the participation of the countries in the implementation of the work and the financing should come this fall. There are competing projects at the European Space Agency, and it may turn out that they will win out. The intentions of France also hinge largely on this decision.

"The first phase of the planning is now under way," declared Barsukov. "Much is still unclear. But the project is obviously of interest, and it should be an international project. We are ready to expand the framework of the collaboration. The door stands open to any country to participate in the Vesta project. The tasks are huge, and there is work enough for all".

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Comments on U. S. Opposition to Soviet Imagery Sales, 'Resurs' Remote Sensing System
Leningrad LENINGRADSKAYA PRAVDA in Russian
31 Dec 87 p 3

[Interview with Arnold Selivanov, doctor of technical sciences: "Mutually Advantageous Commerce or Embargo Games?"]

[Text] APN [Novosti Press Agency] Scientific Observer Mikhail Chernyshov talks with doctor of technical sciences Arnold Selivanov, one of the leading specialists at USSR Glavkosmos, on problems of the commercial use of space.

[Question] Not so long ago the NEW YORK TIMES informed its readers that American geologists liked Soviet space photographs of the surface of the Earth and would like to acquire them from USSR Glavkosmos. But, the newspaper asserted, it seemed as though the Reagan Administration was doing everything to prevent this commercial transaction. Could you comment on the newspaper report? [Answer] In roughly the 1970s the USSR and U.

S. began to create specialized satellites for remote sensing. In 1972 the Americans placed in orbit their first apparatus of this type, the Landsat satellite. Somewhat later the Soviet Meteor-Priroda satellite appeared. Later similar systems were also developed in other countries. In particular, the French Spot system, operational since 1986, can be mentioned. The number of countries that consume space information also increased rather rapidly. In other words, by now a supply and demand market has developed in this sphere.

When it spoke about geologists the NEW YORK TIMES had in mind the U. S. Geological Service, which is engaged in the preparation and sale of maps, observations of the territory of the country for earthquakes, monitoring the purity of watersheds and other similar tasks. Some types of work require not merely space photographs, but photographs with a certain resolution, in particular those on which small objects can be seen. Soviet space photographs offered to purchasers today are the best in the world. Objects up to five meters in size can be distinguished on them. For comparative purposes, photographs obtained by the French Spot system distinguish details down to 10 meters in size, and the American Landsat makes it possible to identify objects of no less than 30 meters in size. By purchasing the Soviet photographs the U. S. Geological Service, naturally, would gain certain advantages. But it looks as though the U. S. administration and the American military departments in this case are concerned least of all with commercial questions. Here the political aspects are clearly being placed in the forefront. From the standpoint of common sense it is completely impossible to understand how the acquisition of Soviet photographs by American geologists can "threaten U. S. national security." But precisely these assertions are being advanced by the American administration.

[Question] A curious overall picture is taking shape in the sphere of the commercial use of space. The American authorities are preventing by every effort, say, the import into the USSR of both American satellites, and space apparatus of other countries, if these apparatus are manufactured with the use of American components, for launch by Soviet rockets. They explain the ban on imports by expressing concern about preserving technological secrets. However, with respect to the photographs it is the opposite situation. Essentially the USSR is offering American consumers its more advanced technology. But it turns out that even this is bad. Even this is fraught with something for the American side.

[Answer] I believe that we need not look for logic here. The goal of the American administration is clear. It is to prevent to the maximum extent possible the appearance of the USSR in the commercial market with its space equipment. And barriers are being erected even to the detriment of its own departments and firms. You see, the prohibitions cause dissatisfaction not only on the part of the U. S. Geological Service, but also of such American concerns as General Electric and General Motors. These

firms are suffering great losses due to the breakdown of schedules for satellite launches. By accepting the Soviet proposals the firms, to the contrary, would gain significant advantage.

[Question] The Soviet Union, obviously, will also develop the sphere of its space services in the future. After all, the market is not only full of American customers, but domestic needs are also tremendous.

[Answer] If we speak about the natural sciences, in our country there exist three types of mutually complementary systems for obtaining information: a non-time-sensitive photographic system and two rapid-operation systems, which are specialized with respect to observation of the land and the oceans. Together these three structural blocks comprise the large state-wide "Resurs" system. The photographic subsystem called "Resurs-F" uses satellites that produce photographs of individual territories and drop the exposed film to earth. This method gives excellent quality photographs, but it has a long cycle for accomplishing consumers' orders. A subsystem solves a number of tasks mainly of a cartographic nature.

In the other two subsystems (they are called "Resurs-O" and "Okean-O") the information is transmitted by radio from the satellites. This provides for observing fast-moving processes, and the rapid delivery of information to the consumers. Information from the remote sensing satellites is received by three stations, at Moscow, Novosibirsk and Khabarovsk. These stations make it possible to observe the entire territory of the country and many contiguous regions. These satellites can store information, and in this regime — memory and subsequent transmission — they are capable of working virtually anywhere on Earth.

[Question] What kinds of work can the satellite systems accomplish? How are relationships with consumers structured?

[Answer] "Resurs-O" type satellites have been placed in orbit since 1980. There have been several modifications of this type of apparatus. For example, the last of this series, "Cosmos-1689" was operational in 1985-1986. The satellite had a television apparatus, which provided images with resolutions of 45, 170 and 200 meters, and had an operating width on the surface of the Earth of 45, 600 and 1,400 kilometers respectively. The onboard apparatus of these satellites are especially suitable, say, for observing the hydrological situation, vegetation, forest fires and the spread of pollution.

"Okean-O" satellites have been launched since 1983. As onboard apparatus they use side-looking radars with resolution of approximately one kilometer and operating width of 450 kilometers. The main purpose of satellites of this type is to observe the ice situation in the Arctic and Antarctic under conditions of cloudy weather and polar night. An important feature of "Okean-O" type

satellites is the ability to transmit information to simplified reception positions, which can be fitted out on ships, polar stations, etc. "Resurs-O" type satellites are still largely experimental in nature. "Okean-O" satellites have entered the normal operating regime.

Within the country all types of photography are carried out according to consumers' orders on a commercial basis. Annually more than 100,000 photographs are distributed to 140 consumers. In the foreign market we offer photographs at \$500 and up. The cost depends on the nature of the photograph and the methods of its processing. In any event, we attempt to establish reasonable prices, which suit both ourselves and the consumers. After he receives a photograph the consumer can make prints of it, re-sell it to other institutions and firms, and carry out any types of processing he requires, using his own equipment.

Space information can be used not only for cartographic or geological purposes. For example, the already mentioned "Resurs-O" satellites worked well in assessing agricultural efforts in several areas of the country, in particular the Volga region. We could also provide such photography to other countries at their request. "Okean O" type satellites are also capable of accomplishing not only oceanographic, but also other natural science tasks, for example the comprehensive study of natural resources in coastal zones.

In conclusion, I would like to say that the attempts by the U. S. administration to conduct a discriminatory policy in the sphere of commercial use of space are having a boomerang effect, and are hitting most of all the interests of the American firms and institutions that are associated with space business. Such an approach can hardly be called constructive. The times demand a search for other ways, for mutually advantageous cooperation, and not for erecting barriers.

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Commercial Agreement for Orbital Materials Processing Signed With FRG Firm

18660090 Moscow VECHERNYAYA MOSKVA in Russian 29 Dec 87 p 1

[Text] Three research experiments will be conducted on board a Soviet spacecraft, "Foton," in 1989-1992 by the "Kaiser-Threde" firm of the Federal Republic of Germany. An agreement in regard to this research has been concluded with the firm by the "Litsenzintorg" organization, on instructions from the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos).

It was reported in Glavkosmos that this is the first commercial agreement which Soviet organizations have concluded with foreign partners in the field of space technology involving production of substances with unique properties that appear impossible to obtain in

terrestrial conditions. Results of studies of semiconductor materials, alloys and protein structures may be of tremendous value for development of processes of the future, including ones for biotechnology and genetic engineering. "Kaiser-Threde" will produce equipment and deliver it to the Soviet Union. After experimental containers have been in orbit, they will be returned to the firm.

FTD/SNAP 08309

U.S. Tracking Facilities to Participate in 'Phobos' Project

18660041 Tallinn SOVETSKAYA ESTONIYA in Russian 22 Nov 87 p 3

[Excerpt] One of the USSR's largest radio telecommunication complexes, which is located in the Crimea, and an American spacecraft tracking station will operate jointly during the flight of Soviet automatic stations to Phobos, a satellite of the planet Mars. A group of U.S. scientists and Soviet colleagues spent several days discussing details of this unique experiment. On 20 November they signed a working memorandum defining the scope of preparations for this expedition and setting deadlines for their completion. Scientists and engineers of 12 countries and the European Space Agency are taking part in the expedition.

Permanent automatic space stations are expected to land on the surface of Phobos in April of 1989. At precisely this critical moment, American space-communications stations will be enlisted in ensuring radio communication with the spacecraft and transmission of data to Earth.

The American specialists met for several days with scientists and engineers of the Institute of Space Research, worked at the Flight Control Center in suburban Moscow, and were shown space telecommunications systems.

FTD/SNAP 9738

INMARSAT Considers Expansion of Services

18660038 Moscow VODNYI TRANSPORT in Russian 10 Nov 87 p 4

[Article by Yu. Atserov, chairman of the All-Union Marine Satellite Communications Association of the USSR Ministry of the Merchant Fleet]

[Abstract] The article reports on results of the fifth session of the assembly of the International Marine Satellite Communications Organization (INMARSAT), which took place recently in London.

The author relates that 51 countries now belong to INMARSAT. Equipment for satellite-aided communications has been installed on more than 250 Soviet vessels, and preparations for adding three second-generation

satellites to the INMARSAT system are in progress. It is recalled that representatives of INMARSAT and the British Aerospace firm, which produces second-generation communications satellites, visited the Baykonur Cosmodrome in October of this year and were favorably impressed by the Cosmodrome's space launch equipment. Soviet "Proton" rockets are said to possess a number of advantages for launching satellites of the INMARSAT type. The author points out, however, that the U.S. State Department has opposed the use of Soviet rockets on the grounds that this might lead to leaks of secret information. The assembly recommended further study of this problem by the INMARSAT council.

The author goes on to relate that preparations are being made in the USSR and other INMARSAT member-countries to begin using satellite communications for airplanes during the next two years. Ratification of documents authorizing such a step is expected to be completed this year. Participants of the assembly's session also supported the idea of broadening services provided by INMARSAT for mobile communications units on land. Mention is made in this connection of plans for creating a new international satellite communications organization, INTELSAT, in the near future. It is to serve all types of non-mobile communications facilities on the ground, while all types of mobile communications services of land and air transport are to be included in the INMARSAT system.

FTD/SNAP /9738

Call for Creation of Leningrad Regional Center for Space Earth-Resources Studies

18660037 Leningrad LENINGRADSKAYA PRAVDA in Russian 5 Nov 87 p 4

[Article by K. Kondratyev, academician; V. Sevast'yanov, pilot-cosmonaut of the USSR; A. Buznikov, Doctor of Technical Sciences; O. Smotkiy, Doctor of Physical-Mathematical Sciences]

[Excerpt] Experience of past decades has demonstrated that placing payloads with large masses into orbit alone does not guarantee the ultimate success of space experiments. We frankly admit that insufficiently high quality of onboard measuring equipment and speed for processing large arrays of information have lowered the effect of end results in our country.

[As compared with the 1960s], space information now requires substantially larger expenditures of time and money for processing and mathematical interpretation with the aid of modern high-speed computers. Because of this, very valuable information often is lost completely, without reaching users who have a material interest in it.

Scientists and specialists of the Leningrad region could make a large contribution to solving these problems. A decision to organize a scientific council in this city for space research in the interest of the economy was adopted quite recently by the presidium of the USSR Academy of Sciences.

However, the presence of a large number of highly qualified specialists at Leningrad higher schools and scientific institutions makes it possible realistically to raise the question of creating not only a public agency but also a state interbranch territorial center for the study of Earth resources from space in our region. Such a center could develop methods and equipment for remote sensing in the interest of solving regional problems of protecting the natural environment of the Northwest and utilizing its natural resources efficiently. A considerable number of acute problems of this nature have accumulated in our region, beginning with the ecology of the Gulf of Finland and Lake Ladoga, which is the main source of drinking water for the residents of Leningrad.

Unfortunately, the Northwest is not the only area where there are no regional space research centers. As a result, our industry and agriculture still are not receiving proper economic benefits from space research because of chaotic organization, bureaucratic rigidity and the narrow departmental approach, despite the great scientific-technical potential which our country possesses in the field of space research. Pilot-cosmonaut of the USSR V. Dzhanibekov spoke of this with concern recently on a television program, "Spotlight on Restructuring". He emphasized that the problem consists mainly in the reluctance of certain leading officials to take on additional responsibilities connected with utilization of space information.

FTD/SNAP /9738

Discussions at Moscow Space Forum

18660036 Moscow IZVESTIYA in Russian 4 Oct 87 p 2

[Article by B. Kononov and S. Mushkaterov, correspondents]

[Abstract] The article records conversations with foreign participants and remarks made by principal speakers at the international forum "Cooperation in Space in the Name of Peace on Earth", which was in progress in Moscow.

"Space and Ecology" and "Space for Health" were among the topics of round-table discussions held at the forum. The "Space and Science" discussion group was broken down into sections entitled "Research of the Solar System", "Research of Space Plasma", "Astrophysics of High Energies" and "Radio Astronomy from Space". At the section on research of the solar system, L.V. Ksanfomaliti of the USSR Academy of Sciences' Institute of Space Research told about the progress of the

international program "Phobos". It calls for spacecraft-aided studies of the sun, the interplanetary medium, the atmosphere of the planet Mars, and the Mars satellite Phobos to begin in 1988. A permanent scientific station is to be placed on the surface of Phobos.

V.L. Barsukov, corresponding member of the USSR Academy of Sciences and director of the Institute of Geochemistry and Analytical Chemistry, related that not only Mars but the asteroids and the larger planets have now become the main focus of space probes. The "Phobos" project is an intermediate stage in a long-term program of Mars research which the Soviet Union has proposed. Subsequent stages involve the placing of vehicles on the planet's surface to gather and study soil samples, and development of a large Mars rover with a service life of two to three years for more detailed study of the planet. Preparation of a manned mission to Mars by the joint efforts of different countries could begin as early as the mid-1990s, according to Barsukov. He mentioned that plans for research of Mars have been discussed with French scientists, and that participation in these projects is open to all other countries.

Yu. P. Kiyenko, director of the state center "Priroda" spoke during the round-table discussion "Space and Economics". Commenting on the progress of spacecraft-aided studies of the earth's surface, Kiyenko noted that space technology is now being used in the accomplishment of 300 specific tasks in agriculture, geology and many other branches of the economy, and that the number of such tasks is expected to increase to 2,000.

FTD/SNAP /9738

Tajik Facility Said To Be Optical Observatory, Laser Charge Denied

18660094 Moscow PRAVDA in Russian
2 Jan 88 pp 1, 3

[Article by A. Pokrovskiy, correspondent (Nurek, Tadzhik SSR)]

[Abstract] The article gives an account of a visit to an observatory complex on Sanglok Mountain in the Tadzhik republic. This complex, which is still under construction, is said to be located near the Afghan border, about 16 kilometers from the Nurek Hydroelectric Station. The author responds to a U.S. television report and statements by Western specialists which were made after the complex was photographed from a commercial satellite last year. It is recalled that some Western commentators, speculating as to the complex's nature, assumed that it was a laser installation possibly intended for military purposes, such as destroying satellites in orbit.

The Sanglok Mountain complex is said to include an astronomical observatory of the Tadzhik Academy of Sciences' Institute of Astrophysics, and an optical observatory which is still being completed. The optical observatory is being built for a different organization, which is

not identified. In 1985-1986, observations of Halley's Comet were made from the astrophysics institute's observatory in line with the "Vega" project, it is recalled. The comet was photographed at a time when its stellar magnitude was only 22. Candidate of Physical-Mathematical Sciences Nikolay Kiselev, head of the institute's department of variable stars, and Galina Chernova, a science associate, commented on activities of the observatory and on its cooperation with foreign scientists. Features of the atmosphere at the high-elevation site enable the observatory's telescope, which is 1 meter in diameter, to achieve results comparable to those obtained with larger instruments, according to Kiselev and Chernova. Flights of the spacecraft "Luna-16," "Luna-17" and "Zond-8" were observed and bursts from their engines during orbital corrections were even recorded from the observatory, for example. Construction personnel at the site of the optical observatory claimed that power transmission lines of the complex are intended for supplying electricity for scientific instruments, computers and everyday needs; the capacity of these lines is not large enough for lasers, it was pointed out.

The optical observatory is said to be intended for observation of meteorites, asteroids and artificial Earth satellites. The reasons for this are explained as follows: "With the advancement of cosmonautics, high orbits, including so-called highly elliptical and quasi-stationary ones, have become accessible for use. In the Soviet Union, such orbits are used for spacecraft of the 'Molniya,' 'Astron,' 'Prognoz,' 'Raduga' and 'Ekran' types, for example."

"At the same time, monitoring and tracking of satellites at such distances from the Earth is no longer possible with the aid of existing radar equipment. New equipment operating in the passive mode, including optical-electronic equipment, has therefore been developed lately. The new observatory on Sanglok is to operate on approximately the same principles [as the U.S. "Geodss" system]. Specialists see no violations of the Antimissile Defense Treaty on either side in this case."

Photographs of the astrophysics institute's observatory, of N. Kiselev, and of G. Chernova working with the 1-meter telescope are given. A fourth photograph shows a building of the optical observatory which is under construction. A number of antennas and observation towers, which are located on a hill beyond the building, appear in this photograph.

FTD/SNAP 08309

Prospects for 'Space Civilizations' Viewed at IAF Congress

18660039 Moscow PRAVDA in Russian 2 Nov 87 p 4

[Article by A. Pokrovskiy, correspondent (Brighton and Moscow)]

[Abstract] The article reports on results of the 38th congress of the International Astronautical Federation, which took place recently in Brighton, England. Some of the speeches and papers which were given at this congress are quoted, and conversations with participants are recorded. Among the Soviet participants were academician V. Raushenbakh, who spoke on the progress of space research with practical applications, and O. Shishkin, a representative of the Ministry of General Machine Building. This ministry took part in the development of the "Energiya" rocket.

Topics discussed at the congress reportedly included work on long-distance space probes using interplanetary stations, progress in developing closed biological systems for spacecraft, and prospects for creating permanent industrial facilities and human communities in outer space and on the moon. V. Barsukov, corresponding member of the USSR Academy of Sciences, and academician Oleg Georgiyevich Gazenko, director of the Institute of Medical-Biological Problems, are quoted in regard to research which has a bearing on these problems. A paper presented by Barsukov dealt with comparative studies of mechanisms of birth, life and death in self-regulating systems, including both planets and living systems.

Gazenko related that several generations of insects of the genus *Drosophila* have been bred in zero gravity on biological Earth satellites. No deviations from the norm have been observed in these insects or in viviparous fish which were born on satellites. No natural obstacles to the birth of human beings in space have been discovered as a result of these experiments. Commenting on speculation in regard to the possibility of "space civilizations" made up of persons whose entire lifetimes are spent in space, Gazenko suggested that human evolution might proceed differently in space than on Earth. As a result of this process, inhabitants of space communities might develop resistance to certain space conditions but would eventually become incapable of adapting naturally to terrestrial ones. professor K. Feoktistov reportedly has advanced a similar hypothesis.

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